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The Aviation System Analysis Capability Noise Impact Model

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November 1998

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SUMMARY

To meet its objective of assisting the U.S. aviation industry with the technological challenges of the future, the National Aeronautics and Space Administration (NASA) must identify research areas that have the greatest potential for improving the operation of the air transportation system. Therefore, NASA seeks to develop the ability to evaluate the potential impact of various advanced technologies. By thoroughly understanding the economic impact of advanced aviation technologies and by evaluating how these new technologies would be used within the integrated aviation system, NASA aims to balance its aeronautical research program and help speed the introduction of high-leverage technologies. To meet these objectives, NASA is building an Aviation System Analysis Capability (ASAC).

NASA envisions the ASAC primarily as a process for understanding and evaluating the impact of advanced aviation technologies on the U.S. economy. ASAC consists of a diverse collection of models, data bases, analysts, and other individuals from the public and private sectors brought together to work on issues of common interest to organizations within the aviation community. ASAC also will be a resource available to the aviation community to perform analyses; provide information; and assist scientists, engineers, analysts, and program managers in their daily work.

The ASAC Noise Impact Model (NIM) has been developed as part of the ASAC. Its primary purpose is to enable users to examine the impact that quieter aircraft technologies and/or operations might have on community noise impact and on air carrier operating efficiency at any of 16 large- and medium-sized U.S. airports. These are Atlanta (ATL), Boston (BOS), Cincinnati (CVG), Dallas-Ft. Worth (DFW), Detroit (DTW), Newark (EWR), Washington-Dulles (IAD), New York-Kennedy (JFK), Los Angeles (LAX), New York-La Guardia (LGA), Orlando (MCO), Minneapolis (MSP), Chicago-O'Hare (ORD), Pittsburgh (PIT), Seattle (SEA), and San Francisco (SFO).

To use the NIM, an analyst selects an airport and case year for study, chooses a runway use configuration and set of flight tracks for the case, and has the option of reducing noise of the aircraft that operate at the airport by 3, 6, or 10 decibels. A default annual-average runway use pattern is available for each airport. This is the current existing configuration and may incorporate preferential runway use patterns due to community noise restrictions. For some airports, NIM provides, as an

alternative scenario, a more efficient runway use configuration that could be used if noise were not an issue. Alternate runway use patterns, capacity, and delay values are available for three airports: Los Angeles International (LAX), Chicago's O'Hare International (ORD), and San Francisco International (SFO). Like-wise, two sets of flight tracks are available for 11 airports: one that represents current conditions, including noise abatement tracks, which avoid flying over noise-sensitive areas; and a second set that offers more efficient routing in or out of the terminal area. The remaining five airports do not use noise abatement tracks, so no alternate flight tracks are provided for DFW, DTW, IAD, ORD, and PIT.

NIM computes the resultant noise impact and, for some airports, reports the change in airfield capacity and delay associated with the efficient runway use configuration, and reports the time and distance saved from using the more efficient, alternate flight tracks. The relationship between runway use patterns and airport capacity is a new capability with this release of NIM. Previously, the capability to analyze flight tracks was provided through the stand-alone Flight Track Noise Impact Model (FTNIM). Both functions are now combined and use the same noise and impact calculation algorithms.

Noise impact is characterized in three ways: the size of the off-airport noise contour footprint, the number of people living within the various contours, and the number of homes located in the same contours. The change in airfield capacity is estimated by comparing the difference in the number of peak hourly arrivals and departures for the noise abatement pattern with the more efficient runway use configuration. Delay is estimated as a function of capacity and demand. Flight track time and distance savings are calculated by comparing the noise abatement flight path length to the more efficient alternate routing.

The current version of NIM is designed for World Wide Web implementation. Access is through the ASAC home page (http://www.asac.lmi.org). Two shell programs are used for all input, case processing, and output. The first of these, the NIM Core program, is used to define the parameters for a single airport case, process the inputs, compute noise impacts, and display the results in tables (not graphically). The second shell program, the NIM Batch program, can be used to select and process multiple pre-built airport cases and provide output in tabular and graphical format; maps show the airport vicinity and computed noise contours. The model is designed to be simple to run; a single airport scenario may take from 5 minutes to an hour, depending on the complexity of the case.

Noise calculations are performed using the core modules of the FAA's Integrated Noise Model (INM) Version 4.11. Population and housing counts are computed using an algorithm that incorporates 1990 census data, modified to account for population growth and nonresidential areas such as the airport property and nearby water bodies. The geographic information system is built on MapInfo Pro-Server, a commercially available mapping software package for network applications.

We recognize that modifying runway usage patterns or relocating aircraft flight patterns are technically and politically sensitive issues. This model is intended as a simple analysis tool and does not presume to offer prescriptions for actual airfield operation. Some airports and airlines have suggested that operational changes may be possible in certain circumstances. However, existing noise mitigation programs at most airports cannot be modified without further technical review and open public involvement. The options included in NIM provide important insights into the relationship between noise abatement and airline efficiency to guide research, not public policy.

INTRODUCTION

This introduction reviews NASA's role and objectives with regard to the U.S. aviation industry. Our past research into the relationship between noise abatement and airline efficiency is highlighted, describing the proposed uses for the ASAC Noise Impact Model (NIM). The second section describes, in general, terms how the model works. The third section provides a more thorough report of the program's flow and methodology. The fourth section presents a sample case. Then, the final section offers conclusions.

NASA's Role in Promoting Aviation Technology

The United States has long been the world's leader in aviation technology for civil and military aircraft. During the past several decades, U.S. firms have transformed this position of technological leadership into a thriving industry with large domestic and international sales of aircraft and related products.

Despite its historic record of success, the difficult business environment of the recent past has stimulated concerns about whether the U.S. aeronautics industry will maintain its worldwide leadership position. Increased competition, both technological and financial, from European and other non-U.S. aircraft manufacturers, has reduced the global market share of U.S. producers of large civil transport aircraft and cut the number of U.S. airframe manufacturers to only one (following the recent Boeing acquisition of McDonnell Douglas).

The primary role of the NASA in supporting civil aviation is to develop technologies that improve the overall performance of the integrated air transportation system, making air travel safer and more efficient, while contributing to the economic welfare of the United States. NASA conducts much of the basic and early applied research that creates the advanced technology introduced into the air transportation system. Through its technology research program, NASA aims to maintain and improve the leadership role in aviation technology and air transportation held by the United States for the past half century.

The principal NASA program supporting subsonic transportation is the Advanced Subsonic Technology (AST) program. In cooperation with the Federal Aviation Administration and the U.S. aeronautics industry, the goal of the AST program is to develop high-payoff technologies that support the development of a safe, environmentally acceptable, and highly productive global air transportation system. NASA measures the long-term success of its AST program by how well it contributes to an increased market share for U.S. civil aircraft and aircraft component producers and to the increased effectiveness and capacity of the national air transportation system.

NASA's Research Objective

To meet its objective of assisting the U.S. aviation industry with the technological challenges of the future, NASA must identify research areas that have the greatest potential for improving the operation of the air transportation system. Therefore, NASA seeks to develop the ability to evaluate the potential impact of various advanced technologies. By thoroughly understanding the economic impact of advanced aviation technologies and by evaluating how those new technologies would be used within the integrated aviation system, NASA aims to balance its aeronautical research program and help speed the introduction of high-leverage technologies. To meet these objectives, NASA is building an ASAC.

Goal of the ASAC Project: Identifying and Evaluating Promising Technologies

The principal goal of ASAC is to develop credible evaluations of the economic and technological impact of advanced aviation technologies on the integrated aviation system. These evaluations would then be used to assist NASA program managers to select the most beneficial mix of technologies for NASA to invest in, both in broad areas, such as propulsion or navigation systems, and in more specific projects within the broader categories. Generally, engineering analyses of this kind require multidisciplinary expertise, possibly using several models of different components and technologies, giving consideration to multiple alternatives and outcomes.

NIM Background and Purpose

During 1994, Wyle Laboratories ("Wyle") initiated a NASA-sponsored study to analyze the economic impacts of local noise restrictions on air carrier operations. The project goals included documenting which noise abatement measures have the most impact on the way airlines operate and assessing the potential economic value of quieter aircraft technologies. Results of this study are documented in a Wyle research report (WR 96-19) entitled *Aircraft Noise Reduction and Air Carrier Efficiency*.

Since that initial study, the Logistics Management Institute (LMI), with oversight from NASA Langley Research Center, expanded the scope of work and began developing a noise impact model to be integrated into ASAC. This model is intended to help users examine the effects that new aircraft technology may have on the aviation industry.

Our first generation noise impact model, the Flight Track Noise Impact Model (FTNIM), was released in early 1997 as a stand-alone computer program. This model examined the combined effects of quieter aircraft and more efficient flight tracks at eight U.S. airports. This version is described in our NASA Contractor Report (201683) entitled *The Flight Track Noise Impact Model.*

Work under our current task has developed a tool that NASA researchers and others can use to examine how runway use patterns are related to airline operating efficiency and community noise impact. We developed the capability to examine the relationship between more efficient runway usage and community noise impact. This concept, the Runway Use Noise Impact Model (RUNIM), has now been combined with FTNIM. The new merged version is called, simply, the ASAC NIM and will be hosted on the World Wide Web. In addition to incorporating the runway use model for three airports, the scope of the FTNIM analysis capability has been expanded to a total of 16 large- and medium-sized U.S. airports.

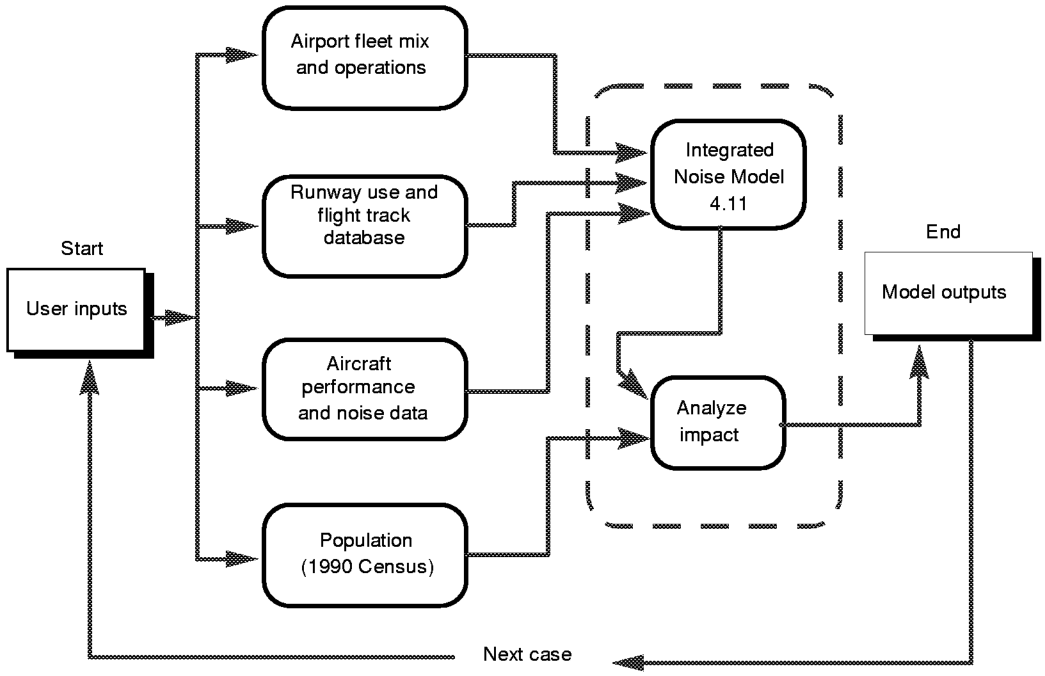
Anticipated Use of the Noise Model

Using NIM, an analyst can ask "How could airline operating efficiency be improved if noise were not a problem at this airport?" To facilitate this analysis, NIM provides a baseline set of noise abatement procedures at 16 airports, enables the user to model quieter aircraft, offers alternative runway use patterns and flight tracks for a subset of these 16 airports, and assesses the community noise impact that results when the quieter airplanes use the alternate procedures. By exercising NIM for successive cases, analysts can determine the reduction in the magnitude of the noise source (one or more specific aircraft types) required to hold the community noise impact constant, or even reduce it, while simultaneously improving airline operating efficiency.

OVERVIEW OF MODEL CAPABILITIES AND ACTIONS

The NIM accesses a collection of databases, gathers and processes the information needed to analyze a user's case, executes two distinct computational actions, and documents the results along with a case history. Each of these functions—database access, case development, computation, and results output—are outlined below and are depicted in Figure 1.

Figure 1. Noise Impact Model Flowchart



Database Access

NIM operates on five types of data derived from the sources noted in the Table 1.

Table 1. Data Types and Sources

Data type	Source
Airport fleet mix and operations	LMI - ASAC
Runway use database	Wyle Laboratories
Flight track database	Wyle Laboratories
Aircraft performance and noise data	FAA - Integrated Noise Model
Population and housing	1990 U.S. Census

Case Development

To develop a scenario, the user chooses one of the three case years for which operations data are available (1993, 2005, or 2015) and selects one of the following 16 airports:

- The William B. Hartsfield Atlanta International Airport (ATL)
- General Edward Lawrence Logan International Airport (BOS)
- Cincinnati/Northern Kentucky International Airport (CVG)

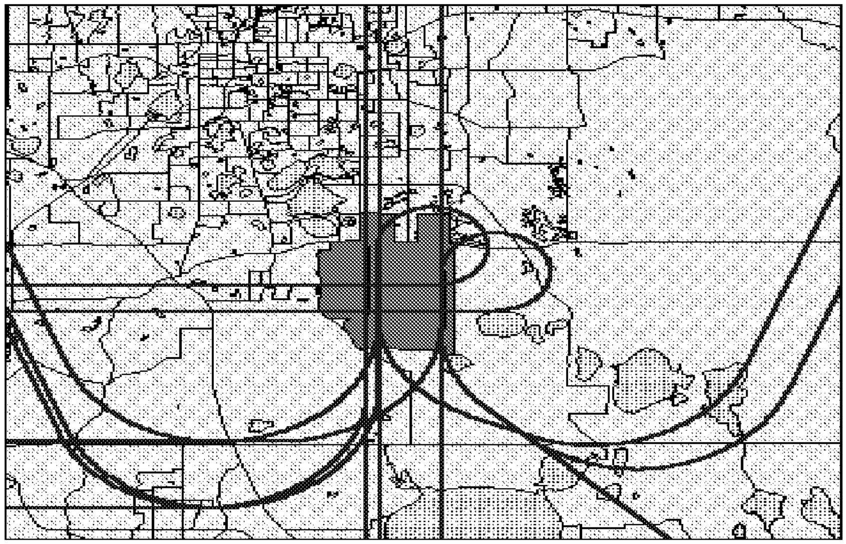
- Dallas-Fort Worth International Airport (DFW)
- Detroit Metropolitan Wayne County Airport (DTW)
- Newark International Airport (EWR)
- Washington Dulles International Airport (IAD)
- John F. Kennedy International Airport (JFK)
- Los Angeles International Airport (LAX)
- La Guardia Airport (LGA)
- Orlando International Airport (MCO)
- Minneapolis-St. Paul International Airport (MSP)
- Chicago-O'Hare International Airport (ORD)
- Greater Pittsburgh International Airport (PIT)
- Seattle-Tacoma International Airport (SEA)
- San Francisco International Airport (SFO).

Once the airport and case year have been chosen, NIM provides the default runway use configuration and flight tracks, which may include noise abatement procedures. For three airports (LAX, ORD, SFO), users have the option of selecting a more efficient runway use configuration. For eleven airport (ATL, BOS, CVG, EWR, JFK, LAX, LGA, MCO, MSP, SEA, and SFO) and/or set of flight tracks that have been developed excluding community noise impact as a factor.

If the runway use configuration is improved, airfield operations become more efficient, potentially improving airfield capacity and reducing delay. If flight tracks are optimized, the existing noise abatement flight tracks are replaced with tracks designed for more direct routing into or out of the terminal area, with associated time and distance savings. The change in airfield capacity and delay, and the time and distance savings from each efficient flight track have been pre-computed.

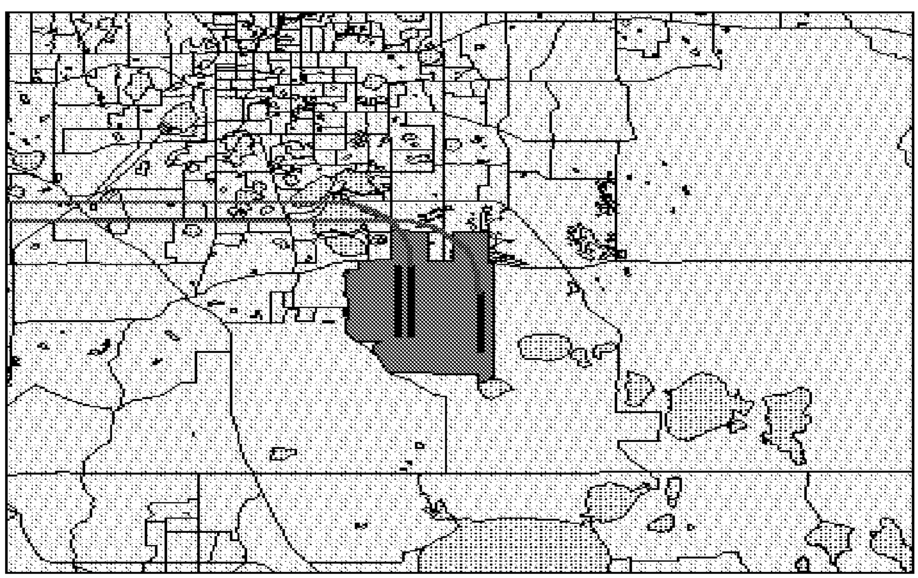
Figures 2 and 3 demonstrate the concept of using more efficient airfield and flight track operation procedures; shown are sample existing and optimized flight tracks for Orlando International Airport. Current noise restrictions limit the use of north-flow runway use configurations due to the dense residential population of Orlando, immediately north of the airport. When aircraft are operating to the north, they must execute a time-consuming flight path to avoid over-flying the populated areas.

Figure 2. Existing Flight Tracks for Orlando International Airport



Note: Two flight tracks execute a 270 degree turn when departing to the north. This routing voids flying over the dense residential population of Orlando, immediately north of the airport.

Figure 3. Optimized Flight Tracks for Orlando International Airport



Note: In this figure, the same two departure flight tracks have been relocated to fly over Orlando. This saves time and fuel for the aircraft operator, but would only be acceptable to the community if the aircraft were quiet enough not to create adverse noise impacts.

The introduction of new technology aircraft, with lower noise characteristics, would potentially increase the use of north-flow configurations and improve air-field capacity. While noise is a factor in determining airfield capacity, there are several other important factors, including wind, weather conditions, air-space management issues, etc. The NIM database of runway use configurations has been developed in cooperation with airport operators to ensure that the assessment of alternate patterns are realistic, given all the other factors that influence airfield operations and capacity.

Scrutiny of flight procedures at most airports reveals that moving flight tracks bring up several air-space management issues. For example, with three large airports sharing the same air-space, the New York Metropolitan Area has a very complex, high-density air traffic environment. A noise abatement flight track at Newark cannot simply be relocated without taking the traffic patterns at La Guardia and Kennedy airports into account. In all cases, we exercised caution in defining alternative routes to ensure that these optimized tracks are realistic in terms of safety, aircraft performance, and air traffic management.

The standard noise abatement and alternate efficient flight tracks for each of the study airports are shown in Appendix A. The time and distance savings estimated for each of the optimized tracks are included in Appendix B.

The numbers of departures for the case airport and year are displayed for four categories of jet-powered commercial aircraft: wide- or narrow-body and short- or long-haul (an equal number of arrivals are assumed). In NIM, a long-haul flight is 1,000 statute miles or more. Figures for each category of aircraft may be increased or decreased at the user's discretion. The number of departures by all other aircraft (i.e., propeller, general aviation, helicopters, and military) will be displayed but may not be changed.

The fleet mix for the facility and year also are displayed, and the user may reduce the modeled noise level for any commercial jet aircraft type by 3, 6, or 10 decibels (dB). NIM also enables users to reduce the noise level of an entire category of aircraft (wide- or narrow-body) in one step and then go back and selectively modify the noise-reduction factors for individual aircraft types.

Computation

NIM exercises two computational modules as part of the analysis. First, it calls up the FAA's INM to compute the noise impact for the user's scenario. Noise impact is defined with a set of noise contours at 60, 65, 70, and 75 dB day-night average sound level (DNL). DNL is the industry standard for evaluating noise impact, and it accounts for the number and type of flights as well as the fleet mix and flight tracks. Operations conducted between 10 p.m. and 7 a.m. are assigned a 10 dB penalty to reflect their greater intrusiveness. The noise contours show which areas around the airport experience the greatest noise and the average noise level. The 1993 baseline DNL contours are shown for all study airports in Appendix A.

Second, NIM exercises a geographic information system (GIS) to compare the noise impact areas with the residential neighborhoods and count the number of homes and people within the noise contours. The GIS module also subtracts the airport property and bodies of water from the noise contour areas computed by INM to give an "off-airport" area of impact, in acres.

Results Output

The NIM Core program reports changes in air carrier operating efficiency, including the change in airfield capacity, estimated delay, and the time/distance saved for operations on each optimized flight track along with measures of community noise impact—the number of acres, homes, and people exposed to significant levels of noise from airport activities. These outputs are provided in a tabular format and can be saved along with the case parameters. The NIM Batch program, in addition to reporting the outputs listed above for the Core program, provides a graphic display of the DNL 60, 65, 70, and 75 contours along with a map of the airport vicinity (including airport boundaries).

NIM OPERATION

This section describes NIM components and provides a sample calculation, step-by-step, to explain the modeling methodology.

Model Components

Several distinct components are combined to provide the modeling capabilities available in NIM: the user interfaces, databases, and computational modules. We created the original user interfaces using the C++ programming language. The Web-based implementation may change the form of these interfaces slightly. However, the data being collected, transferred, and reported will remain as described here.

Although much of the database content is taken from external, verified sources and then reformatted for use by the model, some has been developed in-house. The analytical program modules were written in C programming language. In addition, modules are used from two outside sources: the core noise computation module of the FAA's INM and MapInfo Pro-Server, a geographic information system software package. The various modules are linked through a series of subroutines that process and transfer the data at each stage.

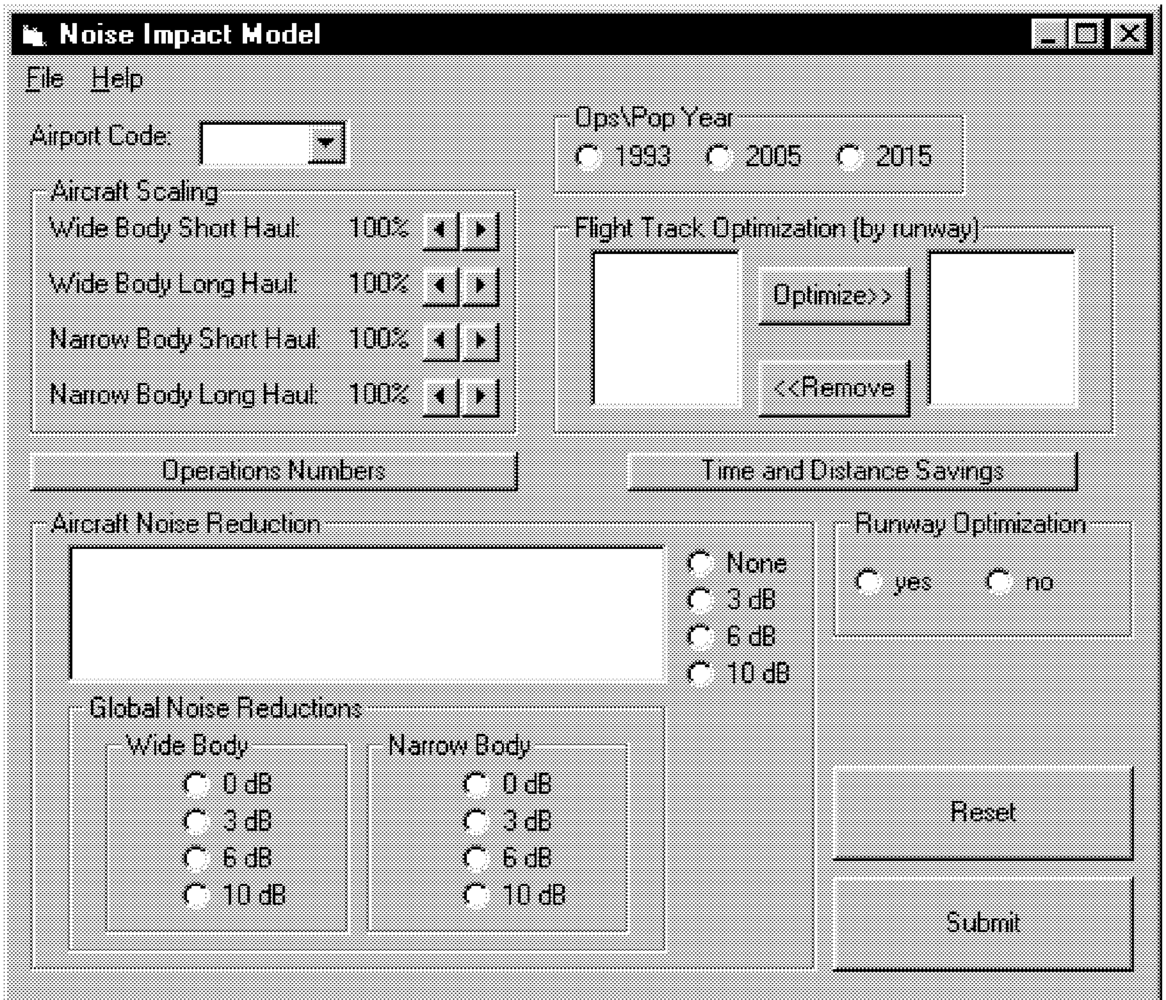
User Interfaces

Analysts use the NIM Core program to build and process a single airport case and output the results in tabular format. The NIM Batch program can be used to process multiple airport cases and display results in a tabular and graphical format.

NIM Core Program Input Screen

The input screen for the NIM Core program is shown in Figure 4. Users select the airport by its three-letter code at the top left of the screen and the case year (i.e., "Ops/Pop Year") to the top right. Next, users specify whether the runway use configuration is to be optimized or not. NIM then populates a table of available runways.

Figure 4. NIM Core Program Input Screen



Users select the individual runways for which they want the flight tracks to be optimized. Once a runway is selected, tracks using that runway will be optimized, and the runway designator shifts from the left-hand to right-hand column. Selecting the [Time and Distance Savings] button shows the time and distance saved, in seconds and nautical miles respectively, for each operation on the flight tracks being optimized.

Alternate runway use configurations can be activated by using the pair of yes/no buttons to the right of the input screen (the default is "no"). For the three airports for which alternate runway use schemes are available, the user may select the "yes" button. Then, NIM will configure the airport case to activate a different runway utilization percentage. This option may be selected along with alternate flight tracks or by itself. The results will be printed on the output statement. All capacity and delay values have been pre-computed as shown in Table 2.

Table 2. Alternate Runway Use Effects.

Airport	Default Capacity (ops/peak hr)	Default Delay (min/op)	Alternate Capacity (ops/peak hr)	Alternate Delay (min/op)
LAX	89.27	12.50	89.27	12.41
ORD	100.26	10.36	103.95	10.26
SFO	47.70	12.025	48.20	10.68

Four categories of aircraft are displayed in the upper left portion of the screen and their numbers of departures can be scaled up or down. Selecting the [Operations Numbers] button displays the operations for each category, reflecting the user's scaling choices.

The aircraft in the fleet for that airport, in that case year, are listed in the center of the screen and can be modified to reduce their noise by 3, 6, or 10 dB. Similarly, a global noise reduction can be applied to the categories of wide-body and narrow-body aircraft. Once a global noise reduction is set, the user still has the option of changing it for selected aircraft in the fleet. Making changes to individual aircraft types will turn the button off that shows a global setting. That global setting, however, is still applied to other aircraft in the category. Using the [Reset] button clears all fields. This is the only way to disable a global selection, once one has been made.

The [Submit] button executes the analysis once the user is satisfied with the scenario. If the user prefers to use the Batch mode for processing, she must save the case as a file. These saved case files will automatically be given an .SCN file extension.

Within NIM, graphical output can only be viewed using the Batch program shell, not the Core program. However, numerical output from the NIM Core program is provided in the form of an .SLK file, which can be opened by most spreadsheet programs including Excel. The table lists the user's choices for the scenario; changes in airfield capacity and delay; the time and distance savings for each flight operation using the optimized tracks; the aggregate savings in time, distance, and number of operations per year, by aircraft type; and the noise impact statistics.

Figure 5 shows a typical output table with results for a notional airport ("COM") in 2005 with optimized runway use configuration, optimized flight tracks on two of the runways, all operations levels kept at their defaults, and the noise levels for narrow-body aircraft reduced by 10 dB.

Figure 5. Sample NIM Output Table

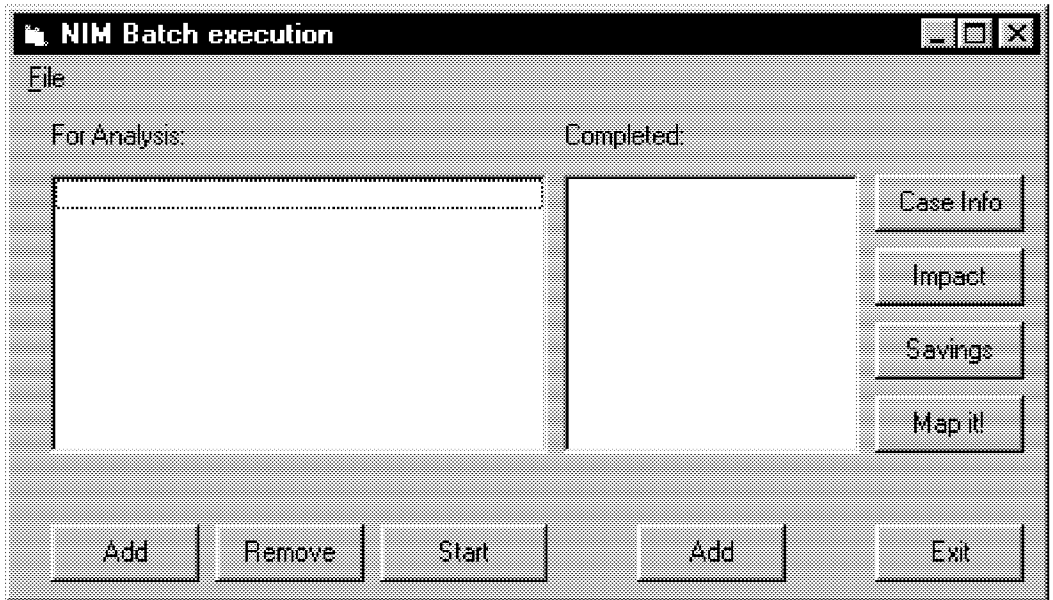
Airport Efficiency Scenario Report For				**COM**
Execution date		01-Oct-97		
Year	Runways optmized?	Flight track optimization (by runway)		
2005	Yes	35L, 36R		
Noise reductions				
Narrow-body aircraft 10 dB				
Changes in airfield capacity and delay				
Standard		Optimized		
Capacity(ops/hr)	Delay (min/opn)	Capacity(ops/hr)	Delay (min/opn)	
36	33	37	24	
Time and distance savings per operation per track				
Track	Time (sec)		Distance (nm)	
6	41		5.5	
10	39		5.2	
Aggregate savings per aircraft type				
Aircraft	Time (min/year)	Distance (nm/year)	Operations/year	
735	14	111.5	21.6	
72F	2.4	18.9	3.7	
Noise impact statistics				
Noise Contour	Population (people)	Housing (units)	Census Area (sq. acres)	
60 DNL	9339	3384	13484	
65 DNL	1291	458	3662	
70 DNL	178	55	491	
75 DNL	16	5	21	

NIM Batch Program Input Screen

The input screen for the second shell, the NIM Batch program, is shown in Figure 6 and follows the same approach as the Core program. Two functions can be performed by this program: batch mode processing of pre-built airport cases and the display of output information for each case. Under the "For Analysis:" window, the [Add], [Remove], and [Start] buttons are used to add pre-built cases to the list for batch processing, remove a case, and begin NIM computations for each case, respectively. Results of the NIM processing are automatically stored in a CASES subdirectory. Once a batch of cases is run from this shell program, all their associated files will appear in the "Completed:" list. These case results then are available for viewing.

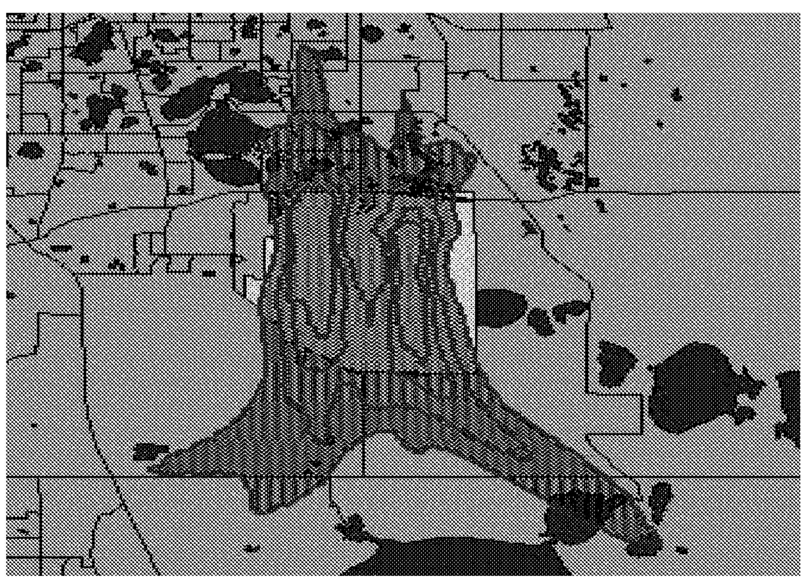
Under the "Completed:" window, the [Add] button is used to add one or more processed cases to the list for viewing program output. If the user wants to use the Batch program to review the results of an earlier case, or a case analyzed by pressing the [Submit] button in the Core program, the user simply enters the case file name in the list of "Completed" files, using the [Add] button.

Figure 6. NIM Batch Program Input Screen



Output data are is accessed by selecting one of four buttons: [Case Info] provides the airport code, study year, and the percentage scaling used for each of the aircraft categories; [Impact] reports the population, housing, and acreage for the DNL 60, 65, 70, and 75 contours; [Savings] reports the change in airfield capacity, delay, and the time and distance savings resulting from more efficient runway use patterns and less circuitous flight tracks and [Map it!] displays a picture of the airport vicinity overlaid with DNL 60, 65, 70, and 75 noise contour intervals—as shown for Orlando International Airport (MCO) in Figure 7.

Figure 7. NIM Batch Program Graphic Output



Databases

The NIM integrates data drawn from a variety of sources into a comprehensive library providing the following information:

The INM database, INM input files, and/or airport sources provide the following data:

- Sixteen airports, their runways, height above sea level, and average temperature (these data are listed in Appendix C)
- Runway utilization for 1993 operations at each airport, by aircraft category
- The flight tracks used for arrivals and departures on each airport runway
- Flight track utilization statistics for each aircraft type
- The typical descent profiles for each aircraft type and several climb profiles, depending on how heavily loaded the aircraft is with fuel (more fuel for longer flights)
- Noise data for each operational profile for each aircraft type.

The ASAC relational database provides data about the specific types of aircraft operating at each airport, the number of departures executed during 1993, the operations levels projected for 2005 and 2015, and the average stage length each aircraft flies at that facility.

Wyle Laboratories provides the following data:

- Capacity and delay values for the existing preferential runway usage patterns (based upon combined input from LMI-computed capacity delay data and airport/airline evaluations)
- Alternate runway utilization by aircraft category for optimized scenarios, the associated capacity and delay values for (LAX, ORD, and SFO).
- Alternate flight tracks designed to provide greater operating efficiency compared with existing noise-abatement flight procedures and the time and distance saved for ATL, BOS, CVG, EWR, JFK, LAX, LGA, MCO, MSP, SEA, and SFO
- A table translating the types of aircraft noted in the *Official Airline Guide* (OAG) into the equivalent types recognized by the INM.

The U.S. Census and commercially available databases provide these data:

- Population and housing densities surrounding each airport, subdivided geographically into census blocks
- Information defining the airport boundary and nearby bodies of water
- Airport property graphics.

Computational Modules

The two key computational modules in NIM are the FAA's INM and the airport noise impact calculation module using the geographic information system Map-Info Pro-Server.

INM Version 4.11

The industry standard for analyzing noise impacts from aircraft operations around airports is the FAA's INM. This model was originally developed in the early 1970s and has been upgraded several times since then. According to a recent FAA statement:

> The model is used by over 700 organizations in 35 countries to study changes in noise impact from new or extended runways or runway configurations, new traffic demand and fleet mix, revised routings and airspace structures, alternative flight profiles and modifications to air traffic control procedures.

Source code for the core modules of INM Version 4.11 (in Fortran) has been incorporated into NIM. To date, attempts to insert the comparable INM version 5.0 code into NIM have failed due to the unavailability of separable software modules.

Geographic Information System for Assessing Noise Impact

This methodology starts with the INM noise contours and census data, but it uses a population density distributed uniformly throughout the census block rather than assuming all people reside at the centroid of the census block. The algorithms also examine the surrounding land uses to discount the airport property and nearby bodies of water. The resultant assessment of the number of people and homes impacted is much more accurate than if the contour areas were applied directly to the population density defined for the census blocks.

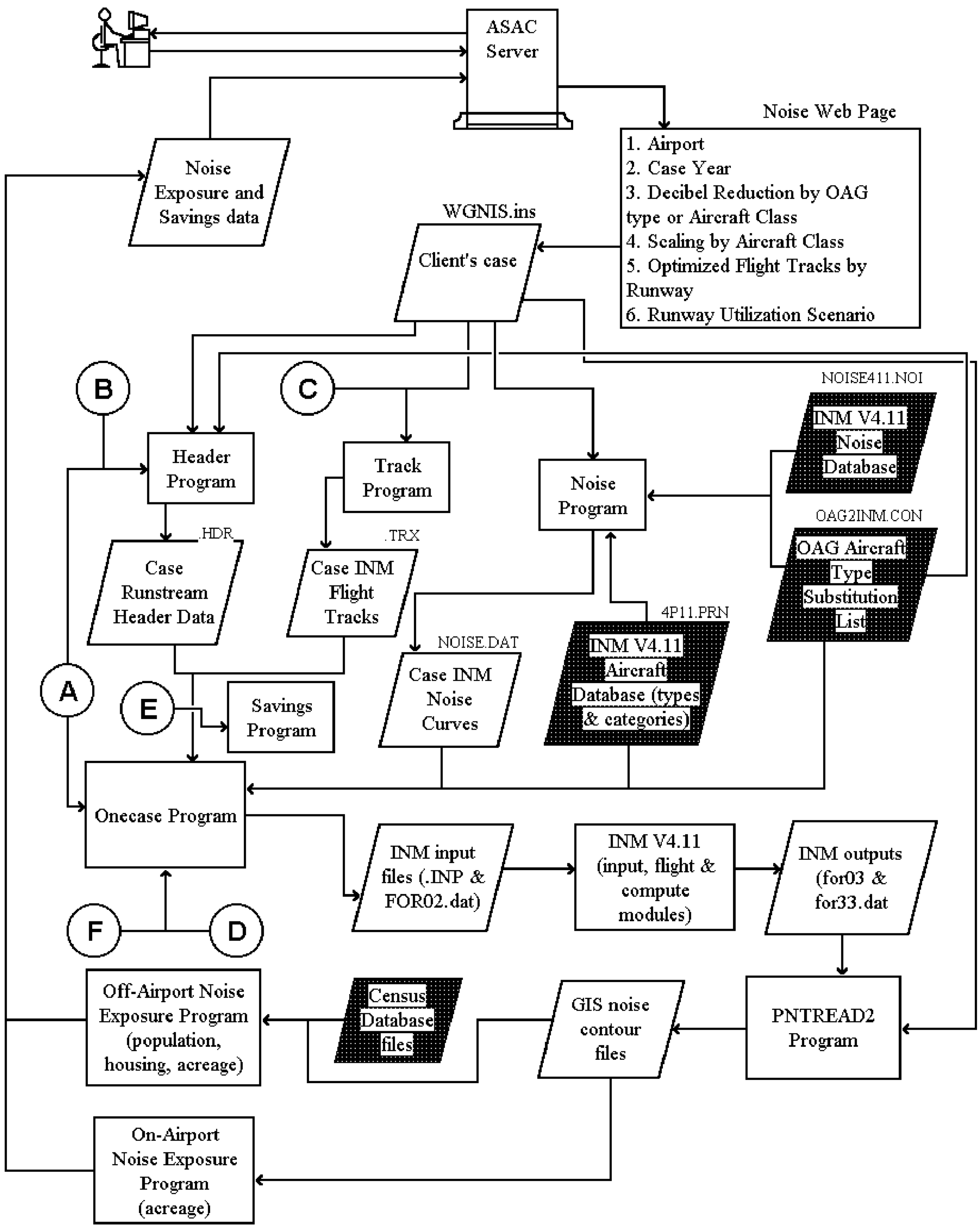
NIM uses the network mapping software, MapInfo Pro-Server, to integrate the noise level, land use, and census data into a comprehensive noise impact map that can be analyzed for the areas, population, and houses located within each of the contour bands for a given user scenario.

Connecting the Components

The connection and communication among the various components is accomplished through a set of customized routines that we developed for NIM. The functions of these routines are quite varied, from data preprocessing and user-selection translation, to geographic mapping conversions. Some of these functions were performed during the development of FTNIM and NIM and the results incorporated into databases. Other functions are activated each time NIM operates.

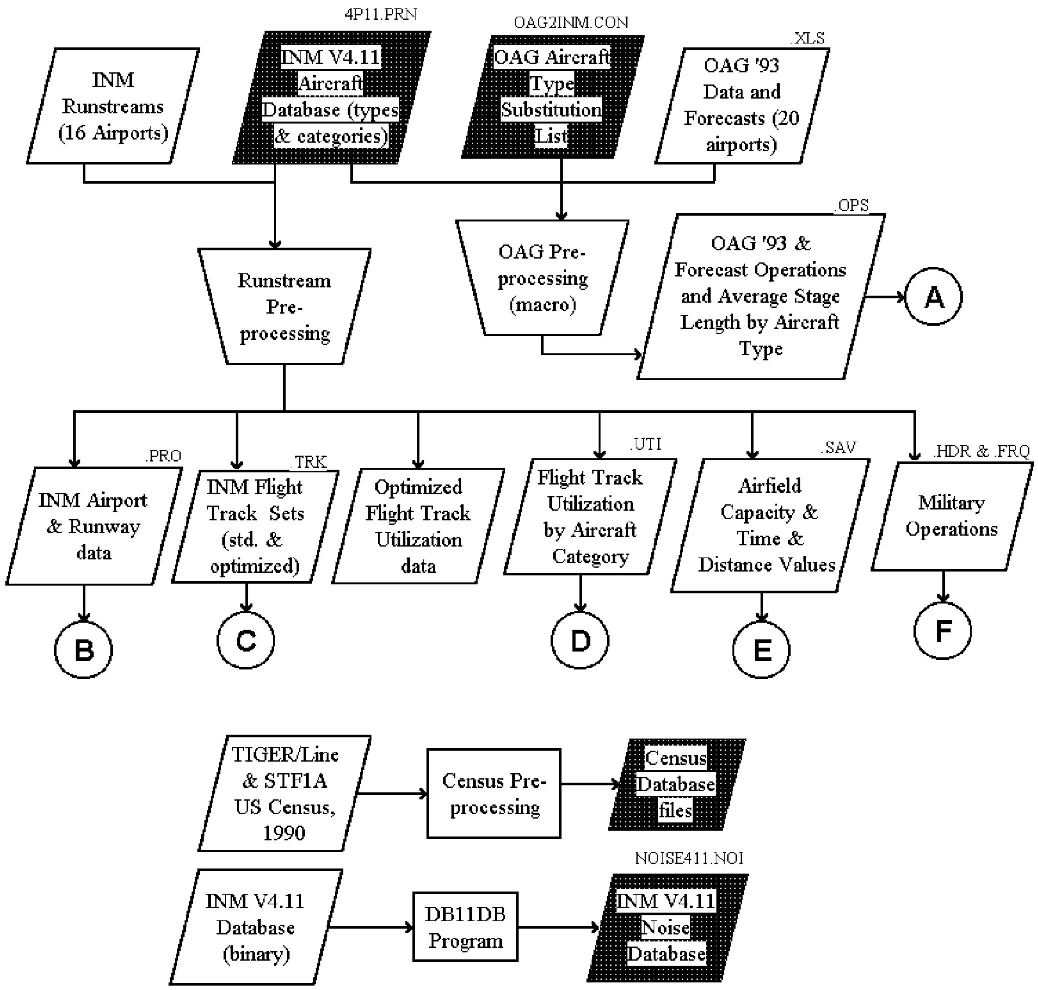
Figure 8 shows the data flow for NIM. When the model is fully integrated into ASAC, users will access the model through the ASAC server and make a series of choices, setting up the Client Case shown in the center top portion of the figure. At this point in the process, the Client Case exists as a set of data selections. At each stage, routines are required to evaluate the user's scenario and collect the necessary data from the databases. Then, the required operations are performed on the data to prepare them for use by the next program module. Several intermediate data files are created and used. These actions are described more fully in the Sample Calculation section of this report. All data groups and data tables appear in Figure 8 as parallelograms, while computational program elements are shown in boxes.

Figure 8. Data Flow for the NIM



In Figure 8, the circled letters A through F indicate points in the analysis where data are provided by subroutines not shown in the figure. These actions, shown in Figure 9, preprocess the data for integration into the other program elements.

Figure 9. Data Preparation for the NIM



SAMPLE CASE

This section describes a sample calculation and the data on which the calculations are based. There are three subsections: the first describes the databases used to perform the calculations and the steps used to preprocess the data. The second contains the calculation steps. The third subsection discusses the accuracy of the model.

Database Preparation and Data Preprocessing

Four databases are used in the entire process. Each one is described below. Data preprocessing consists primarily of the analysis of INM runstreams (input files) and OAG operations data.

INM AIRCRAFT TYPES AND CATEGORIES DATABASE (4P11.PRN)

The pertinent data in this file are the INM aircraft types from the V 4.11 database and their associated aircraft category (sample below). The two aircraft categories of "narrow-body" and "wide-body" have been established by the aviation industry.

Sample INM Version 4.11 database file section:

												0-500	500-1000	1000-1500	1500-2000	2500-3500
INM_ACID	INM_NO	DESCRIPTION	COS	CATNAME	NOI#	NOINAME	NOISTAGE	Body	E/B	LDP_NAME	LDP_ID	TOP_S1	TOP_S2	TOP_S3	TOP_S4	TOP_S5
747100	1	B747-100/JT9DBD	COS	JCOM	6	JT9DBD	1	W	4EWB	STD3D	1	1	2	3	4	5
747200	2	B747-200/JT9D-7		JCOM	7	JT9DFL	2	W	4EWB	STD3D	2	7	8	9	10	11
74710Q	3	B747-100QN/JT9D-7QN		JCOM	7	JT9DFL	2	W	4EWB	STD3D	3	14	15	16	17	18
747SP	4	B747SP/JT9D-7		JCOM	7	JT9DFL	2	W	4EWB	STD3D	4	20	21	22	23	24
74720B	5	B747-200/JT9D-7Q		JCOM	50	JT9D7Q	3	W	4EWB	STD3D	5	27	28	29	30	31
DC820	6	DC-8-20/JT4A	COS	JCOM	1	JT4A	1	N	4ENB	STD3D	6	34	35	36	37	38
707	7	B707-120/JT3C	COS	JCOM	1	JT4A	1	N	4ENB	STD3D	7	40	41	42	43	44
720	8	B720/JT3C	COS	JCOM	1	JT4A	1	N	4ENB	STD3D	8	46	47	48	49	50
707320	9	B707-320B/JT3D-7	COS	JCOM	2	JT3D	1	N	4ENB	STD3D	9	51	52	53	54	55
707120	10	B707-120B/JT3D-3	COS	JCOM	2	JT3D	1	N	4ENB	STD3D	10	58	59	60	61	62
720B	11	B720B/JT3D-3	COS	JCOM	2	JT3D	1	N	4ENB	STD3D	11	64	65	66	67	68
DC850	12	DC-8-50/JT3D-3B	COS	JCOM	2	JT3D	1	N	4ENB	STD3D	12	69	70	71	72	73
DC860	13	DC-8-60/JT3D-7	COS	JCOM	2	JT3D	1	N	4ENB	STD3D	13	75	76	77	78	79
DC870	14	DC-8-70/CFM56-2C-5		JCOM	4	CFM562	3	N	4ENB	STD3D	14	82	83	84	85	86
BAE146	15	BAE 146-200/ALF502R-5		JCOM	5	AL502R	3	N	4ENB	STD3D	15	89	90	91		
707QN	16	B707-320B/JT3D-7QN		JCOM	3	JT3DQ	2	N	4ENB	STD3D	16	92	93	94	95	96
DC8QN	17	DC-8-60/JT8D-7QN		JCOM	3	JT3DQ	2	N	4ENB	STD3D	17	99	100	101	102	103
CONCRD	18	CONCORDE/OLY593		JCOM	8	OLY593	1	N	4ENB	STD3D	18	106	107	108	109	110
DC1010	19	DC10-10/CF6-6D		JCOM	11	CF66D	3	W	3EWB	STD3D	19	112	113	114	115	116

OAG AIRCRAFT TYPE SUBSTITUTION LIST (OAG2INM.CON)

This file lists the OAG aircraft types and the comparable INM aircraft type on the basis of noise levels each aircraft generates (Table 2). "OAG_A_Profile" shown in column 3 indicates the departure climb profile used for each aircraft's operations. "STD3D" is the standard default climb procedure specified for each aircraft type. It defines engine thrust, climb gradient, and air speed as functions of the distance from the start of takeoff roll.

Table 3. Sample OAG to INM Substitution List

OAG_type	INM_type	OAG_A_profile	Description
310	A310	STD3D	Airbus A310 (all series)
320	A320	STD3D	Airbus A320
727	727Q7	STD3D	Boeing 727 passenger jet (all series)
72F	727EM2	STD3D	Boeing 727 freighter (200)
733	737300	STD3D	Boeing 737-300
734	737400	STD3D	Boeing 737-400
743	74720B	STD3D	Boeing 747-300 SUD
744	747400	STD3D	Boeing 747-400
757	757RR	STD3D	Boeing 757 (all series)
75F	757RR	STD3D	Boeing 757-200pf freighter
763	767300	STD3D	Boeing 767-300/300ER
767	767CF6	STD3D	Boeing 767 (all series)

Census Database Files (.TAB, .MAP, .ID, .DAT, .IND)

The NIM census database files contain three different sets of data: cartographic data, population data, and households data. To achieve this, three different databases have been combined and processed:

- TIGER/Line census files (1990, 1992, and 1995 releases), which provided the cartographic data
- Census summary tape file 1A (STF1A), which provided the framework for the population and households data
- Woods & Poole Economics, Inc. 1994 regional forecast and database, from which the actual population and households information were extracted.

The TIGER/Line files database is a product of the U.S. Bureau of Census and consists of selected geographic and cartographic information extracted from the U.S. Census Bureau's TIGER database. For this project, only the cartographic information was needed. These data represent the structure definition of the polygonal shapes that when combined make up the census areas of the different counties of interest. The criterion for selecting the counties was that they had to be located, even if only partially, within a 20-mile radius from the chosen airport. The degree of resolution of the resulting maps was chosen to be at the "block group" level since that is the maximum resolution common to all the types of census data that were needed. A block group is a combination of census blocks that is a subdivision of a census tract or Block Numbering Area (BNA).

Once extracted, the selected TIGER/Line database data were refined by removing bodies of water and airport property from the analysis. This step was necessary in order to obtain a more accurate representation of the actual population and households distribution and density after joining the population and households data with the cartographic data. If such refinement had not been done, the resulting map would have had population and households equally distributed between land and water, or airport property, where these happened to be included in the same block group. In the context of census data, households are defined as occupied housing units.

The 1990 Census STF1A is another product of the U.S. Census Bureau containing data about all persons and housing units in the United Sates. The data extracted from this database were used, however, only to calculate the coefficients necessary to derive the population and households figures for each county block group from the county totals. This procedure was necessary because the U.S. Census Bureau provides forecasts for only a few years into the future and the database that contained required projections had only a county-level resolution. The population coefficients were calculated as follows:

$$Coeff_{POP} = \frac{BG_{POP}}{Cty_{TOTPOP}}$$

where:

$Coeff_{POP}$ = Population coefficient

BG_{POP} = Block group population figure

Cty_{TOTPOP} = County total population figure

The households coefficients also were calculated in the same manner:

$$Coeff_{HOUS} = \frac{BG_{HOUS}}{Cty_{TOTHOUS}}$$

where:

$Coeff_{HOUS}$ = Households coefficient

BG_{HOUS} = Block group households figure

$Cty_{TOTHOUS}$ = County total households figure

The coefficients were then multiplied by the county total population and households data for the years 1993, 2005, and 2015 extracted from the Woods & Poole database giving resultant projected block group figures. This procedure assumes that while the overall population may change by some percentage, the *distribution* of population and households within each county will remain unchanged.

As previously stated, the last database used, the Woods & Poole Economics, Inc. 1994 Regional Forecast and Database, provided the projected data for the years 1993, 2005, and 2015. Woods & Poole used the corrected census data from 1969 to 1992 as a starting point and then developed their forecast using a four-stage process.

First, the forecast for the entire United States was developed. This first projection was needed to provide a "control set" of data. Then, the United States was divided into 183 economic areas (EA) and employment and earnings projections were calculated for each of them. These forecasts then were used in the third stage as the principal explanatory variables used to estimate the population and households figures for each EA. The last stage repeated the process of the previous two stages to create forecasts at the county level. In this stage, the EA figures were used as control values. The main strength of this forecast technique lies in the comprehensiveness of the county database and the integrated nature of the model. In fact, each change in one of the counties effects not only that county, but its neighboring counties as well.

We had to extrapolate the analysis for several geographical areas, including Fairfax (VA), Fairfax City (VA), Falls Church (VA). Prince William County (VA), Manassas City (VA), and Manassas Park City (VA). These areas were grouped together in the Woods & Poole database, but not in the Tiger/Line or in the STF1A databases. As a result, to maintain a consistent data set, coefficients had to be calculated in order to create data sets for each single area. The calculation of the coefficients was performed with the same technique used for the block group data sets. The equations used were the following:

$$AreaCoeff_{POP} = \frac{Area_{POP}}{Set_{TOTPOP}}$$

where:

$AreaCoeff_{POP}$	=	Area population coefficient
$Area_{POP}$	=	Area population figure
Set_{TOTPOP}	=	Set of areas total population figure

and

$$AreaCoeff_{HOUS} = \frac{Area_{HOUS}}{Set_{TOTHOUS}}$$

where:

$AreaCoeff_{HOUS}$ = Area households coefficient

$Area_{HOUS}$ = Area households figure

$Set_{TOTHOUS}$ = Set of area's total households figure

The data necessary to perform these calculation were extracted from the Census 1990 STF1A database.

INM Noise Database (NOISE411.DAT)

This file contains the sound exposure level (SEL) and effective perceived noise level (EPNL) values for slant range distances for all available V4.11 aircraft types as extracted from the FAA's INM database. The slant range distance is the straight line distance between the aircraft and the receiver grid point on the ground.

Preprocessing OAG Operations Data

Operational data for each study airport were provided by LMI and contained the number of operations by OAG aircraft type for the years 1993, 2005, and 2015. For 1993 departures, the data also contain the average stage length in statute miles.[1]

The data are then processed with an Excel macro that, with the help of the INM Aircraft Types and Categories database and the OAG Aircraft Type Substitution List, lists the operations for 1993 and forecast years and, for departures, the average stage length by OAG aircraft type, sorted by the aircraft classes. An aircraft class is defined as the combination of a quantitative descriptor of the stage length (long- or short-haul) and the aircraft category (i.e., narrow-body, wide-body, other). The "long" category is one having a minimum average stage length of 1,000 statute miles (equivalent to INM stage length 3). The Excel macro writes the .OPS file.

Sample .OPS file:

```
"NARROW","LONG",1
"D93",1200,3000,0,0
"WIDE","LONG",1
"744",1200,3500,4240,6020
```

[1] Stage length is defined as the great-circle distance from the airport of origination to the airport of destination.

The sample shown above is for two aircraft, a McDonnell Douglas DC9-30 and a Boeing 747-400. The following information for the DC9 appears in the first two lines; the classification as a narrow-body, long-haul aircraft; "1" for departures; type as a D93; average stage length of 1,200 statute miles; 3,000 annual operations in 1993; 0 operations in 2005; and 0 operations in 2015. Similar data are given in the next two lines for the 747 indicating the same average stage length but increasing numbers of operations.

PREPROCESSING INM RUNSTREAMS

INM runstreams of typical operations for each study airport were obtained and analyzed through semi-automated and manual processes. The products of the preprocessing are up to six files for each airport. These files are described in the following subsections.

INM Airport and Runway Data

The first three sections of each INM runstream containing the airport name/identifier, information on climate, and runway coordinates were extracted and written to the .PRO file.

Sample .PRO file:

```
"AIRPORT","COM"
"ALTITUDE",96,"TEMPERATURE",23.0,"C"
"RUNWAYS",1
"RW","36R","18L",50000,23000,50000,35004,359
```

For notional airport "COM," the airfield altitude is given as 96 feet above mean sea level and the year-round average temperature is 23.0 degrees centigrade. COM has just one runway, designated 36R/18L, with one end point at coordinates (50000, 23000) and the other end point at coordinates (50000, 35004). The actual runway orientation is 359 degrees.

Runway Use Configurations

An airport has one set of runways that can be used in several different configurations depending on weather conditions, wind, air-space management issues, aircraft mix, noise restrictions, etc. Each configuration defines runway use percentages, which potentially affect the airfield capacity.

To look at preferential runway use based on noise and its effect on airport capacity, it is first useful to consider the factors that determine the capacity of an airfield. Aggregate airport capacity is a sophisticated concept, effected by multiple variables. These include the number of gates at the terminal, the overall capacity of the terminal, the number and length of the runways, the capacity of the taxiways, and the parking capacity. Each of these variables is usually affected by several additional factors. For example, the way the runways are combined so that some are used for arrival and others for departure under given weather conditions, has a significant impact on capacity. Further, the navigational aids installed, especially for arrivals, can determine capacity when the weather is poor and instrument flight rules are applied.

Noise compatibility problems, generally caused by residential areas being encroached by airport noise, will cause a community noise problem. If the airport responds to citizen complaints by restricting the use of certain runways, capacity can be affected. Generally, these runway restrictions are formalized in a "preferential runway use plan" that identifies which runways are preferred for arrivals or departures so that noise impacts are minimized. These restrictions may be aimed at nighttime operations only, or may be enforced throughout the day. Generally, however, noise abatement considerations are given less priority than safety and peak hourly capacity issues. So, even when preferential runway use schemes have been defined, they are generally only implemented during off-peak hours.

For the three NIM airports for which an alternate runway use scheme is available, we used ASAC data for the base case capacity and delay values. We, also, used real historical data obtained from airports, as well as, limited assumptions based on this historical data and dialogue with airports relating to optimized runway use configurations. Our data included the capacity and delay values associated with typical runway use configurations. Then, we developed alternative configurations that could be expected to improve the efficiency of aircraft movements. In all cases, we coordinated closely with the airport staff at LAX, ORD, and SFO to be sure our assumptions about alternate configurations were realistic.

First, we used the ASAC configuration-specific capacity data as a starting point. Then, we contacted the airports to determine percentage of time that operations at an airport use a particular runway configuration on an annual basis. This collected information is based on two operational scenarios: (1) the Current Scenario runway use configurations used and (2) the Alternate Scenario runway use configurations that would be used without noise as a consideration. By comparing each runway use configuration to the hourly capacities figures, we derived, based on weighted averages, an Average Annual Hourly Capacity (AAHC) for each scenario. AAHC is a single number descriptor of overall field capacity.

The single number AAHC was necessary because the INM recognizes runway usage in a very different form than normally described by airport operators. INM accepts the assignment of aircraft operations to flight tracks and the attachment of tracks to runways, for an annual average day. This means that information regarding how runways are used in combination (the form of data normally used to analyze capacity) must be translated into utilization percentages for individual runways. In addition, runway utilization framed in terms of different weather conditions must be combined in a weighted average to describe operations for an annual-average day. Our engineers have analyzed airport inputs to reformat them for use in the INM. The capacity values, discussed in more detail below, are determined by the airfield configuration and do not change with the number of operations. So, the capacity remains the same for all three case years, 1993, 2005, and 2015.

The capacity information provided by LMI accounted for four weather conditions, as well as wet and dry conditions. Since, we extracted percentages concerning time in a given weather condition, it was possible to apply this information accurately to any projected runway use configuration developed. The AAHC, derived for the airport's current operational scenario and based on real numbers, provides a valid reference. The percentages relating to capacity changes are based on the estimated time a more efficient configuration would be available. Basing available runway configurations on the factors discussed above, as well as historical wind conditions, we arrived at a runway configuration that would most likely be used without noise as an issue. By analyzing this configuration, a value suggestive of how the AAHC may change, was derived based on the implementation of the new configuration.

Once we developed a rationale for expressing AAHC, each of the three airports was examined to determine the change in capacity that might result from a change in runway use patterns. Many members of the aviation community have expressed the belief that releasing noise concerns and changing runway usage would significantly improve the capacity of the target airfields. Our analysis, however, has not shown the degree of improvement that had been hoped. The primary reason for this is that when airports are experiencing peak demand, they generally relax the noise abatement preferential runway use rules. So, releasing the rules for the rest of the day will provide improvements in efficiency only on the off-peak operations. In effect, the capacity of the airport is not as heavily impacted by noise abatement as many in the industry have expected. For this reason, the change in capacity reported by NIM for LAX, ORD, and SFO (shown in a previous section) reveal an improvements of zero (LAX), one percent (SFO) and 3.7 percent (ORD).

The cost of noise abatement is determined by the delay time incurred at the airport as a result of preferential runway use schemes. These schemes may require longer taxi times to get to the preferred runway, and usually cause delay in waiting for the other aircraft that also must use the designated runway. Once delay values are known, the cost is determined by multiplying the time lost by the cost of operating an airliner including fuel, crew salary, and increased aircraft maintenance requirements. This will generate a dollar amount suggestive of the cost each year to aircraft operators of using preferential runway use programs based on noise.

The basic airfield delay values modeled by LMI were subject to the same limitations noted for the capacity values. That is, the delay related to noise abatement was difficult to discern directly, because noise abatement restrictions are minimized during peak operating hours. Instead, we focused on determining the change in time for ground movements. Ground movements are factored into our analysis in a general way, but without the level of detail that is necessary to "tease out" the specific cause (noise abatement) and effect (special delay) relationship that we were was looking for. Then, our ground delay factor could be used to modify the existing airfield delay values that the our modeling documented.

The methodology for determining ground delay determined likely trends. Therefore, it is not specific enough for use in strategic planning at any of the airports considered. Because significant delays occur primarily during the taxi-out phase of an aircraft journey, only departure operations were addressed in the analysis.

Based on discussion with airport personnel at ORD, LAX, and SFO, we obtained information delineating runway usage. These were broken down into the Current Scenario and Alternate Scenario categories. In addition, we collected data including runway use by day and hour for December 1997 for each airport. This data was cross-referenced with average median delay data, collected from the FAA. The delay data was broken down in the same format for the month of December. Using weighted averages, the average delay was calculated for both the Current and the Alternate Scenarios. The difference in the delay numbers indicated a savings, in minutes, that would likely occur if aircraft were to fly without regard for noise policy. Except for LAX, this savings is one that would most likely effect all aircraft using the most common runway usage configurations at the airport. The delays at LAX, based on dialogue with airside airport operations personnel, would be realized only by cargo operators located on the south side of the airport complex.

INM Flight Track Sets

For each modeled runway of each study airport, the flight tracks from the INM runstream were extracted. These are the default flight tracks. Each default track was studied for potential noise-abatement modifications. If the flight track could be improved to fly a more direct route, the revised track then was considered an "efficient" flight track.

The guidelines used to determine the potential for modifying a default flight track include the following criteria:

- The INM flight track could be clearly associated with other published information an airport provided about its defined noise-abatement procedures. Most airports develop pilot instructions for flying noise-abatement routes. These texts can be compared with the flight track shown in the INM runstream.

- A realistic alternate route could be identified that would be safe, practical in terms of equipment performance, and would not infringe on other active airspace.
- The alternate track would provide measurable distance savings when compared with the existing noise-abatement track.

The standard and associated efficient flight tracks were written to the .TRK file for each study airport, sorted by runway. In some cases, these are tracks that already existed in the INM file but were restricted to commuter operations. In other cases, we defined new tracks based on airport staff input and analysis of other operational and procedural considerations.

The sample file describes some of the flight tracks at COM. The first set of tracks shown is for operations departing from runway 36R. There are five existing abatement tracks called by numbers 2 through 6. The first track, number "2," starts with a straight segment of 5.28 miles. Then, the track turns left 90 degrees through a turn radius of 1.74 miles. The final segment is straight for 50 miles, at which time the aircraft has left the airport's vicinity. Note that the nonabatement track 2 is identical to the abatement track. For the file sample shown here, only track 6 differs between the abatement and nonabatement cases. The abatement procedure includes a turn to the right of 270 degrees, while the nonabatement case turns 90 degrees.

Sample .TRK file:

```
"AIRPORT","COM"
"DEPARTURES",1
"36R",1
"ABATEMENT"
"2","STRAIGHT 5.28 LEFT 90 D 1.74 STRAIGHT 50"
"3","STRAIGHT 5.28 LEFT 20 D 1.74 STRAIGHT 50"
"4","STRAIGHT 1.97 RIGHT 20 D 1.74 STRAIGHT 50"
"5","STRAIGHT 1.97 RIGHT 60 D 1.74 STRAIGHT 50"
"6","STRAIGHT 1.97 RIGHT 270 D 1.74 STRAIGHT 50"
"NON-ABATEMENT"
"2","STRAIGHT 5.28 LEFT 90 D 1.74 STRAIGHT 50"
"3","STRAIGHT 5.28 LEFT 20 D 1.74 STRAIGHT 50"
"4","STRAIGHT 1.97 RIGHT 20 D 1.74 STRAIGHT 50"
"5","STRAIGHT 1.97 RIGHT 60 D 1.74 STRAIGHT 50"
"6","STRAIGHT 1.97 LEFT 90 D 1.74 STRAIGHT 50"
"ARRIVALS",1
"36R",1
"ABATEMENT"
"B","STRAIGHT 50"
"NON-ABATEMENT"
"B","STRAIGHT 50"
```

Flight Track Utilization by Aircraft Class

Using a FORTRAN program, the operations in each INM runstream are grouped by class and summed within each class by flight track. The program then determines the percentage of the associated class' operations occurring on each flight track in daytime, evening (if applicable), or nighttime periods. For example, the program calculates, among all long-haul wide-bodied class of aircraft operations at airport COM, flight track 16 is used 82.1 percent during the daytime and 7.01 percent during the nighttime The program writes the percentages (in decimal format) to one .UTI file representing operations using the standard runway use configuration. A second .UTI file is created in which the operation numbers have been scaled to reflect the optimized runway use scenario.

Sample .UTI file:

```
CLASS,TRACK,DAY,EVE,NITE
"LW","16"," .821"," .00000"," .0701"
```

This sample file shows data for long-haul, wide-bodied aircraft (LW) on track number 16. The values shown indicate that 82.1 percent of the daytime LW flights use this track, no operations occur on it during the evening hours of 7 P.M. to 10 P.M., and 7.01 percent of the nighttime LW operations use it from 10 P.M. to 7 A.M.

Airfield Capacity and Delay Values

The change in airfield capacity is defined by the difference in the number of peak arrivals and departures per hour—for the standard and optimized runway use configurations. The delay is specified in minutes per operation for both configurations. For each study airport, the airfield capacity and delay values for the standard and alternate configurations are stored in the RUNIM.SAV file.

Sample RUNIM .SAV file:

The first pair of numbers is capacity measured in operations per hour and average delay per operation, respectively, for the standard configuration while the second pair of numbers is for the optimized runway use pattern.

```
“COM”

"36","33","37",”24”
```

The first pair of numbers is capacity measured in operations per hour and average delay per operation, respectively, for the standard configuration while the second pair of numbers is for the optimized runway use pattern.

Time and Distance Values

The time spent and the distance traveled by aircraft that use the standard and efficient flight tracks are computed and written to a file. The time spent is computed by dividing the distance traveled in nautical miles by an average cruising speed. This cruising speed is specific to each airport and is computed as the weighted average of aircraft cruising speeds for the aircraft operating at the airport, with the weighting based on the number of daily departures. These data are kept in the .SAV file, which is specific for each airport.

Sample .SAV file:

```
"16","4.8","53"
```

As shown in this file, flight track 16 offers a savings of 4.8 nautical miles and 53 seconds for every operation.

Military Operations

If military aircraft operations exist in the INM runstreams, their runstream header and frequency (operations) data are extracted and written to the .HDR and .FRQ files, respectively. This step is performed prior to determining the Flight Track Utilization by Aircraft Category. The NIM will hold military operations constant for all user scenarios.

Calculation Steps

With the databases and data preprocessing having been covered, it is now appropriate to describe the basic steps necessary to run a user-supplied operational scenario to compute noise-exposure, changes in airfield capacity, and time/distance savings data.

SAMPLE SCENARIO

The following list defines a notional operational scenario:

- Airport: COM
- Case Year: 2005
- Decibel Reduction by OAG type or Aircraft Category:

Table 4. Global Noise Reductions

Aircraft type	Reduction (dB)
Long-haul, wide-body (LW)	0
Long-haul, narrow-body (LN)	3
Short-haul, wide-body (SW)	0
Short-haul, narrow-body (SN)	0

Scaling by Aircraft Category:

Table 5. Aircraft Mixture

Class	Scaling
LW	125%
LN	150%
SW	0
SN	0

- Optimized Runway Use Configuration
- Efficient Flight Tracks by Runway: Runways 35L and 36R

COMPUTING NOISE EXPOSURE DATA

The main goal of this task is to determine the off-airport land acreage, number of dwellings, and population within the noise-exposure contours. This involves the creation of a runstream for the INM based on the user-supplied inputs. The INM then creates the noise-exposure contours that the GIS will use to determine noise impacts. To accomplish the main goal, seven programs are executed: Header, Track, Noise, Onecase, INM, PNTREAD2, and Popcount. Each of these programs is described in the following seven subsections.

Header Program

The Header program determines the INM aircraft types associated with the user's case. It accomplishes this by reviewing the portion of the COM.OPS file (for the year 2005) and assigning the INM aircraft types via the OAG Aircraft Type Substitution List. Along with the COM.PRO preprocessed airport/runway data and the user case description (case year plus options), the list of aircraft types is compiled and written to the COM.HDR file. The "FT." line is an INM descriptor specifying that distances used in flight track descriptions are in feet. This line also could be specified as "NM." to reflect distances in nautical miles.

Sample COM.HDR file:

```
BEGIN.
SETUP:
TITLE <NASA ASAC HYPOTHETICAL CASE CREATED: 12/9/96 3:18:15
PM>
AIRPORT <COM>
ALTITUDE 96 TEMPERATURE 23 C
FT.
RUNWAYS
RW 36R-18L 50000 23000 TO 50000 35004 HEADING= 359
AIRCRAFT:
TYPES
AC 747400 CURVE=74E
AC DC9Q9 CURVE=DC9
```

Track Program

The Track program requires two pieces of information: (1) the user-specified set of efficient flight tracks (standard tracks for all runways except runway 36R) and (2) the COM.TRK preprocessed file, which lists all standard and efficient flight tracks in semi-INM format for COM airport.

The Track program copies the appropriate set of tracks for the user case from the COM.TRK file to the COM.TRX file.

Sample COM.TRX file:

```
"AIRPORT","COM"
"DEPARTURES",1
"36R",1
"ABATEMENT"
"2","STRAIGHT 5.28 LEFT 90 D 1.74 STRAIGHT 50"
"3","STRAIGHT 5.28 LEFT 20 D 1.74 STRAIGHT 50"
"4","STRAIGHT 1.97 RIGHT 20 D 1.74 STRAIGHT 50"
"5","STRAIGHT 1.97 RIGHT 60 D 1.74 STRAIGHT 50"
"6","STRAIGHT 1.97 RIGHT 270 D 1.74 STRAIGHT 50"
"NON-ABATEMENT"
"2","STRAIGHT 5.28 LEFT 90 D 1.74 STRAIGHT 50"
"3","STRAIGHT 5.28 LEFT 20 D 1.74 STRAIGHT 50"
"4","STRAIGHT 1.97 RIGHT 20 D 1.74 STRAIGHT 50"
"5","STRAIGHT 1.97 RIGHT 60 D 1.74 STRAIGHT 50"
"6","STRAIGHT 1.97 LEFT 90 D 1.74 STRAIGHT 50"
"ARRIVALS",1
"36R",1
"ABATEMENT"
"B","STRAIGHT 50"
"NON-ABATEMENT"
"B","STRAIGHT 50"
```

Noise Program

The Noise program creates tables of sound exposure level and effective perceived noise level (noise curves) versus distance in the INM format for aircraft types associated with the aircraft class to which the user requests decibel reductions.

It accomplishes this by first assigning INM aircraft types and classes to the OAG aircraft types in the COM.OPS preprocessed file (for the year 2005) via the INM "aircraft types and categories" database and the "OAG aircraft type substitution list."

The Noise program then copies all the noise curves from the INM noise database applicable to the user's case (long-haul, narrow-bodied departures and narrow-bodied arrivals for our sample case), modifies them by the user's reductions (i.e., 3 dB), and writes the modified noise curves to the NOISE.DAT file in the INM format.

Onecase Program

The Onecase program has two primary functions: (1) It is the engine for computing the number of annual average daily daytime, evening, and nighttime operations by INM aircraft type and stage length for the chosen runway use configuration and applicable flight tracks and (2) it compiles all INM operational data into an INM runstream file.

Onecase computes operations with the Flight Track Utilization by Aircraft Class preprocessed file (COM.UTI); the user-specified scalings by aircraft class (125 percent for long-haul and wide-bodied aircraft and 150 percent for long-haul and narrow-bodied aircraft); the INM aircraft types and categories database; the OAG aircraft type substitution list; and the preprocessed COM.OPS file (year 2005 portion). A sample calculation is described below.

With the help of the INM aircraft types and categories database and the OAG aircraft type substitution list, the program determines that, for the year 2005, the COM.OPS file contains the following annual operations:

- 4,240 long-haul, wide-body departures consisting of only INM aircraft type 747-400, stage length 5
- 624 long-haul, narrow-body departures consisting of only INM aircraft type DC9, stage length 3
- 4,240 wide-body arrivals consisting of only INM aircraft type 747-400
- 624 narrow-body arrivals consisting of only INM aircraft type DC9.

The user-specified scalings would be applied to these annual operations (rounding to the nearest operations for the sake of brevity):

- 4,240 x 1.25 = 5,300 long-haul, wide-body (747-400 stage length 5) departures
- 624 x 1.5 = 936 long-haul, narrow-body (DC9 stage length 3) departures
- 4,240 x 1.25 = 5,300 wide-body (747-400) arrivals
- 624 x 1.5 = 936 narrow-body (DC9) arrivals.

Sample NOISE.DAT file:

```
NOISE CURVES
NC DC9 6 BY 10 6 BY 10
EPNL
THRUSTS 3000 6000 8000 10000 12000 14000
200 92.6 98.4 102.7 107.2 111.8 116.8
400 88.4 94.2 98.5 103.2 107.8 112.9
630 85.1 90.9 95.3 100.0 104.7 109.9
1000 81.4 87.2 91.7 96.5 101.3 106.6
2000 75.4 81.2 85.8 90.6 95.7 101.2
4000 68.4 74.2 79.1 84.2 89.4 95.1
6300 63.1 68.9 74.0 79.5 85.0 91.0
10000 57.0 62.8 68.3 74.1 80.0 86.4
16000 49.5 55.3 61.3 67.6 74.0 81.0
25000 40.8 46.6 53.1 60.0 67.0 74.6
SEL
THRUSTS 3000 6000 8000 10000 12000 14000
200 88.6 93.8 98.3 103.0 107.8 113.1
400 84.8 90.0 94.6 99.2 104.1 109.4
630 81.9 87.1 91.7 96.5 101.4 106.8
1000 78.8 84.0 88.7 93.5 98.5 104.0
2000 73.8 79.0 83.7 88.6 93.6 99.1
4000 67.4 72.9 77.7 82.6 87.8 93.4
6300 63.0 68.2 73.1 78.1 83.3 89.0
10000 57.6 62.8 67.8 73.0 78.2 84.1
16000 51.2 56.4 61.6 66.9 72.4 78.4
25000 44.2 49.4 54.8 60.3 66.1 72.4
NC 747 5 BY 10 5 BY 10
EPNL
THRUSTS 8000 16000 24000 32000 40000
200 100.9 106.6 110.3 112.6 114.6
400 96.2 101.9 105.7 108.0 110.0
630 92.4 98.1 102.1 104.5 106.5
1000 87.8 93.5 97.9 100.5 102.5
2000 79.4 85.1 90.1 93.5 95.0
4000 71.4 77.1 83.2 86.5 88.5
6300 65.9 71.6 77.7 81.1 83.1
10000 59.7 65.4 71.6 75.0 77.0
16000 52.2 57.9 64.9 68.7 70.7
25000 43.3 49.0 57.1 61.4 63.4
SEL
THRUSTS 8000 16000 24000 32000 40000
200 96.3 100.3 103.4 105.8 107.8
400 91.8 95.8 99.1 101.4 103.4
630 88.3 92.3 95.7 98.1 100.1
1000 84.5 88.5 92.0 94.5 96.5
2000 78.4 82.4 86.2 88.9 90.9
4000 71.7 75.7 79.8 82.7 84.7
6300 66.9 70.9 75.2 78.2 80.2
10000 61.3 65.3 69.9 73.1 75.1
16000 54.7 58.7 63.7 67.1 69.1
25000 47.3 51.3 56.8 60.5 62.5
```

The COM.UTI file specifies that, for long-haul, wide-bodied aircraft, departure flight track 16 is used 82.1 percent during the daytime and 7.01 percent during the nighttime. For the long-haul, wide-body departures, departure flight track 16 would contain the following annual average daily operations:

- (5,300 departures/year x 0.821)/(365 days/year) = 12 daytime 747-400 stage length 5 departures per day
- (5,300 departures/year x 0.0701)/(365 days/year) = 1 nighttime 747-400 stage length 5 departures per day.

Similar calculations would be made for the DC9 stage length 3 departures on flight track 16 and for all 747-400 and DC9 arrivals on their respective flight tracks.

The program then combines the computed operations data with the

- COM.HDR file,
- COM.TRX file,
- NOISE.DAT file,
- COMMIL.HDR file, and
- COMMIL.FRQ file.

It generates an INM runstream file COM.INP. The COM.INP file is temporarily renamed FOR02.DAT for purposes of executing the INM.

Integrated Noise Model Version 4.11

The Input, Flight, and Compute modules of the INM are executed. The primary outputs are the FOR03.DAT and FOR33.DAT files, which contain the noise contours in a binary format.

PNTREAD2 Program

The PNTREAD2 program stands for "point read." It reads the binary format contour files generated by the INM and writes GIS noise contour files compatible with MapInfo.

Popcount Program

The Popcount program uses the "point read" files and the preprocessed census database files to compute the off-airport land acreage, numbers of dwellings, and population within each noise-exposure contour.

COMPUTING CHANGES IN AIRFIELD CAPACITY AND DELAY

The savings program utilizes the database of airfield capacity and delay values to compute the differences in capacity and delay between the standard and more efficient runway use configurations. The results are written to the COM.SAV file.

COMPUTING TIME/DISTANCE SAVINGS DATA

The Savings program uses the preprocessed data file of "time and distance values" for all standard and efficient flight tracks (for COM airport) and the user-specified set of efficient flight tracks (tracks on runway 36R only). The program computes the difference in time and distance between activation of the standard and efficient flight tracks and writes the results to the COM.SAV file, similar to the sample .SAV file shown previously.

Model Accuracy and Limitations

NIM relies on accurate input data, as do all computer models, and it makes as few assumptions and approximations as possible, given the intended use of the results. The primary usefulness of NIM is in its ability to model how *changes* in aircraft noise levels and/or flight procedures could affect flight efficiency and community noise impact. The assumptions and approximations noted below have been allowed because they speed processing time without diminution, in our view the utility of the model for its intended purpose.

Overall, it must be noted that the noise calculations, while using the INM, are not sufficiently detailed to be useful for predicting noise impact at any given airport. Wyle, LMI, and NASA strongly discourage users from exercising NIM to assess noise impacts at an airport for other than research purposes. The most recent version of the INM (currently version 5.1) as provided by the FAA, or the most recent version of its military counterpart NOISEMAP, as provided by the Department of the Air Force—always should be used as the primary tool for assessing or predicting aircraft noise impacts.

The definition of a long-haul flight as anything greater than 1,000 statute miles and the grouping of aircraft into long-haul versus short-haul categories is not as refined as most INM runstreams used for airport noise studies. However, the results of comparing one scenario to another are still valid for the level of detail available to most of the aviation industry and for research analysts exploring aircraft technologies.

Similarly, there are considerable differences in the noise characteristics of the various aircraft within the categories "narrow body" or "wide-body." New technologies are likely to be aimed at specific aircraft rather than broad categories, so users may want to apply individual aircraft noise reductions.

The INM itself has certain limitations due to the simplified treatment of how aircraft noise is generated and propagated in air and across varied terrain. Generally, the model is considered accurate within approximately one dB when groups of aircraft are considered. The accuracy diminishes as the aircraft travels farther away from the airport and as there are fewer aircraft in the mix.

CONCLUSIONS

The NIM provides analysts with a convenient tool bringing together four basic functions for studying airports:

- A noise modeling tool for aircraft operations
- Evaluation of the change in airfield capacity and estimated delay associated with using more efficient runway use patterns compared with standard noise-abatement configurations
- Evaluation of the time and distance savings associated with using more efficient flight tracks compared with existing noise-abatement flight tracks
- Accurate evaluation of changes in the off-airport acreage and numbers of people and homes impacted by noise resulting from user-defined changes in runway use, flight tracks, numbers of operations, and aircraft noise levels.

Bibliography

Burn, M., J. Carey, J. Czech, and E. R. Wingrove III. *The Flight Track Noise Impact Model*. NASA Contractor Report 201683, April 1997.

Wyle Research Report WR 96-19. *Aircraft Noise Reduction and Air Carrier Efficiency—Final Progress Repor*t. Wyle Laboratories, Arlington, VA, June 1996.

Appendix A

Flight Tracks and Noise Contours

In this appendix, we graphically display important data for the 16 airports included in the ASAC Noise Impact Model.

Figure A-1. Atlanta International Flight Tracks and 1993 Noise Contours

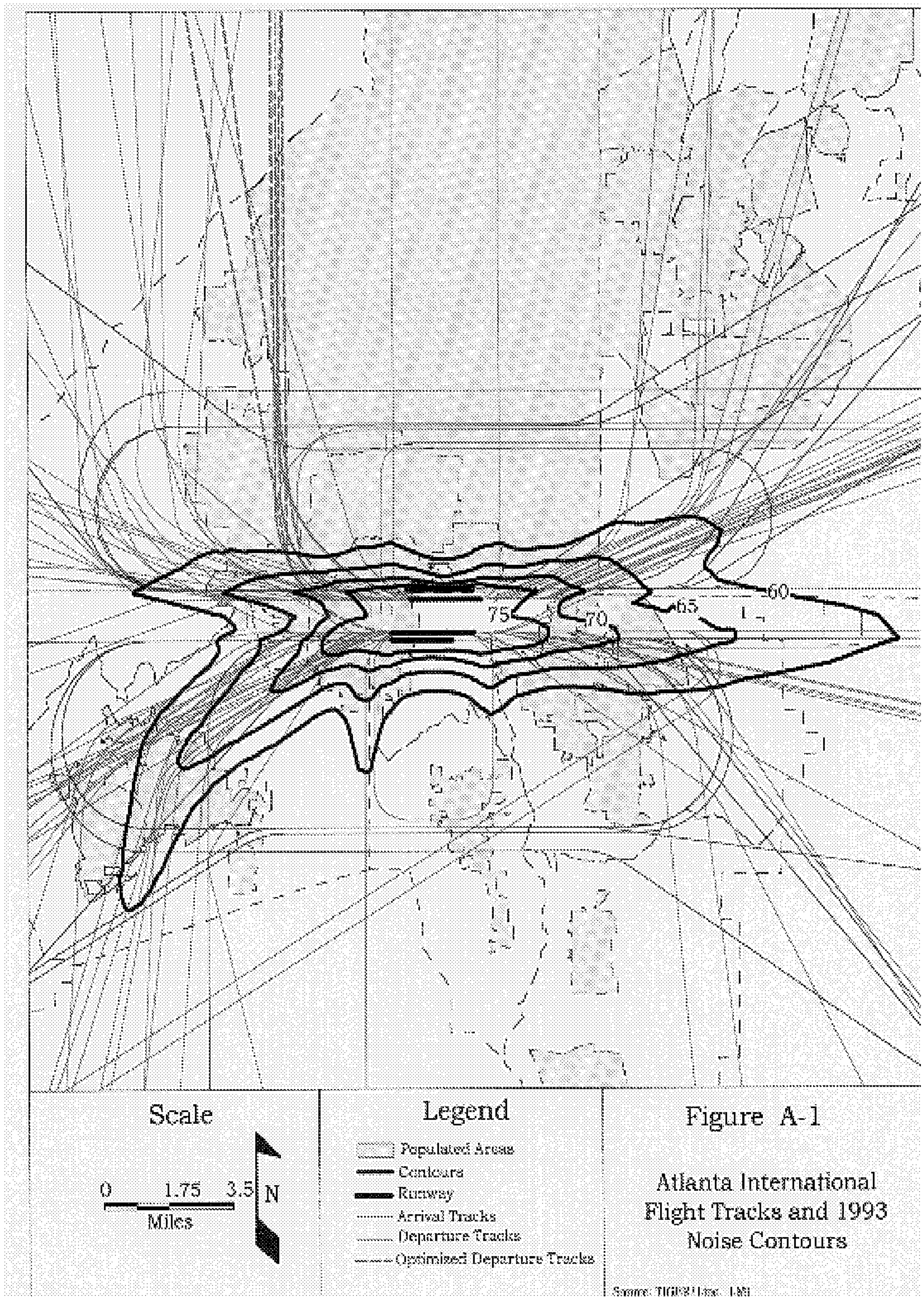


Figure A-2. Boston Logan International Airport Flight Tracks and 1993 Noise Contours

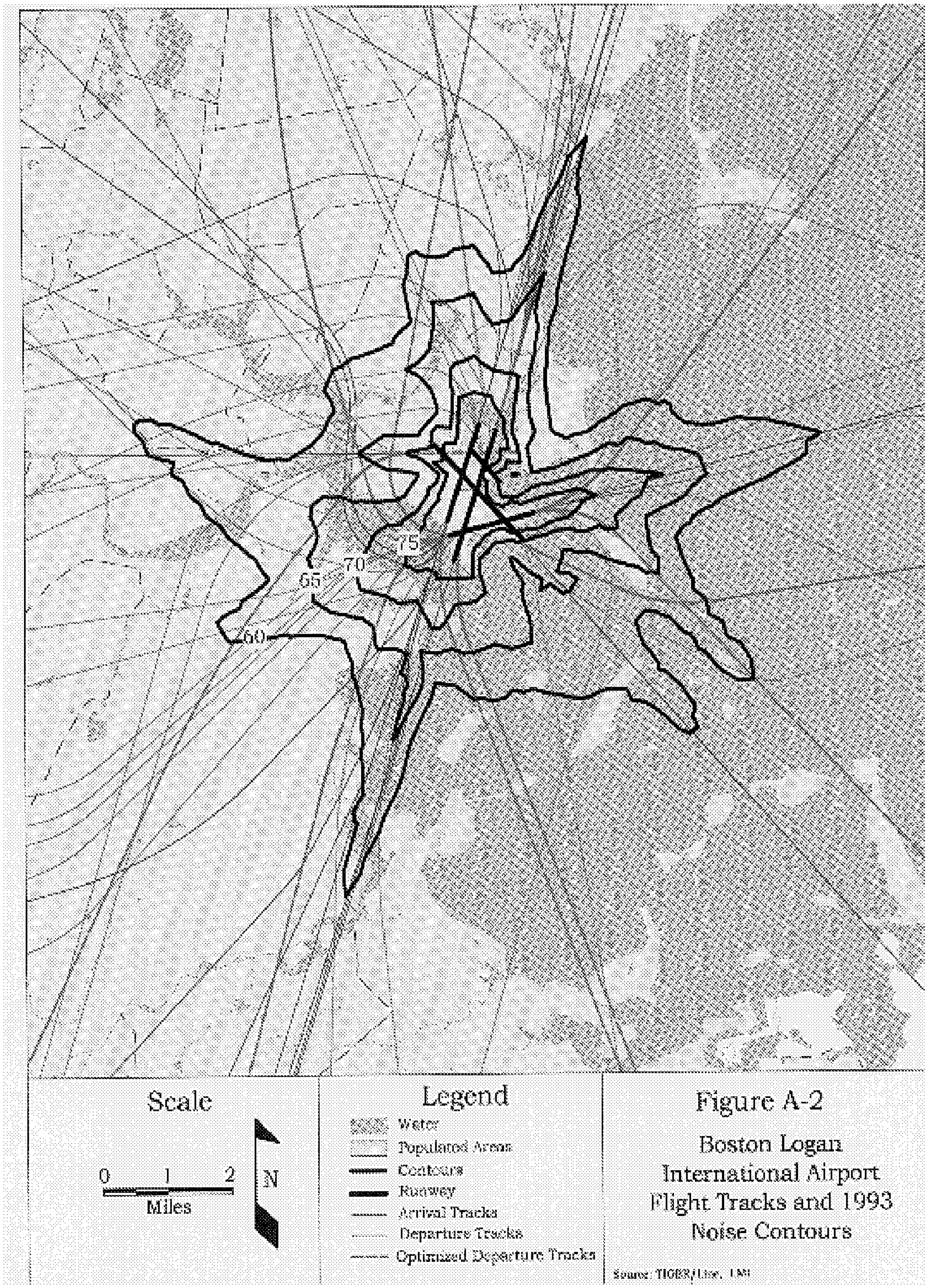


Figure A-3. Cincinnati-Northern Kentucky International Airport Flight Tracks and 1993 Noise Contours

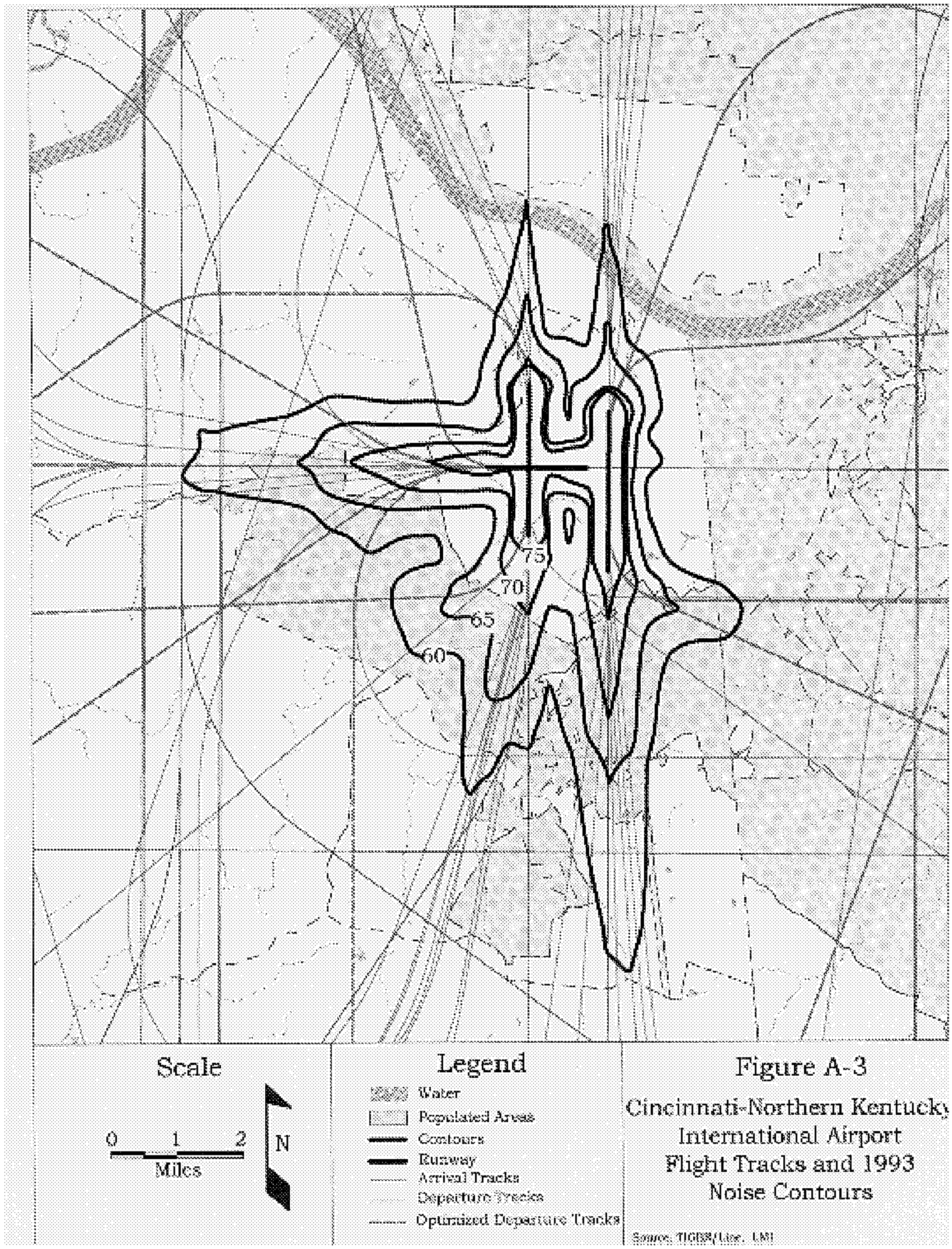


Figure A-4. Dallas/Ft. Worth International Flight Tracks and 1993 Noise Contours

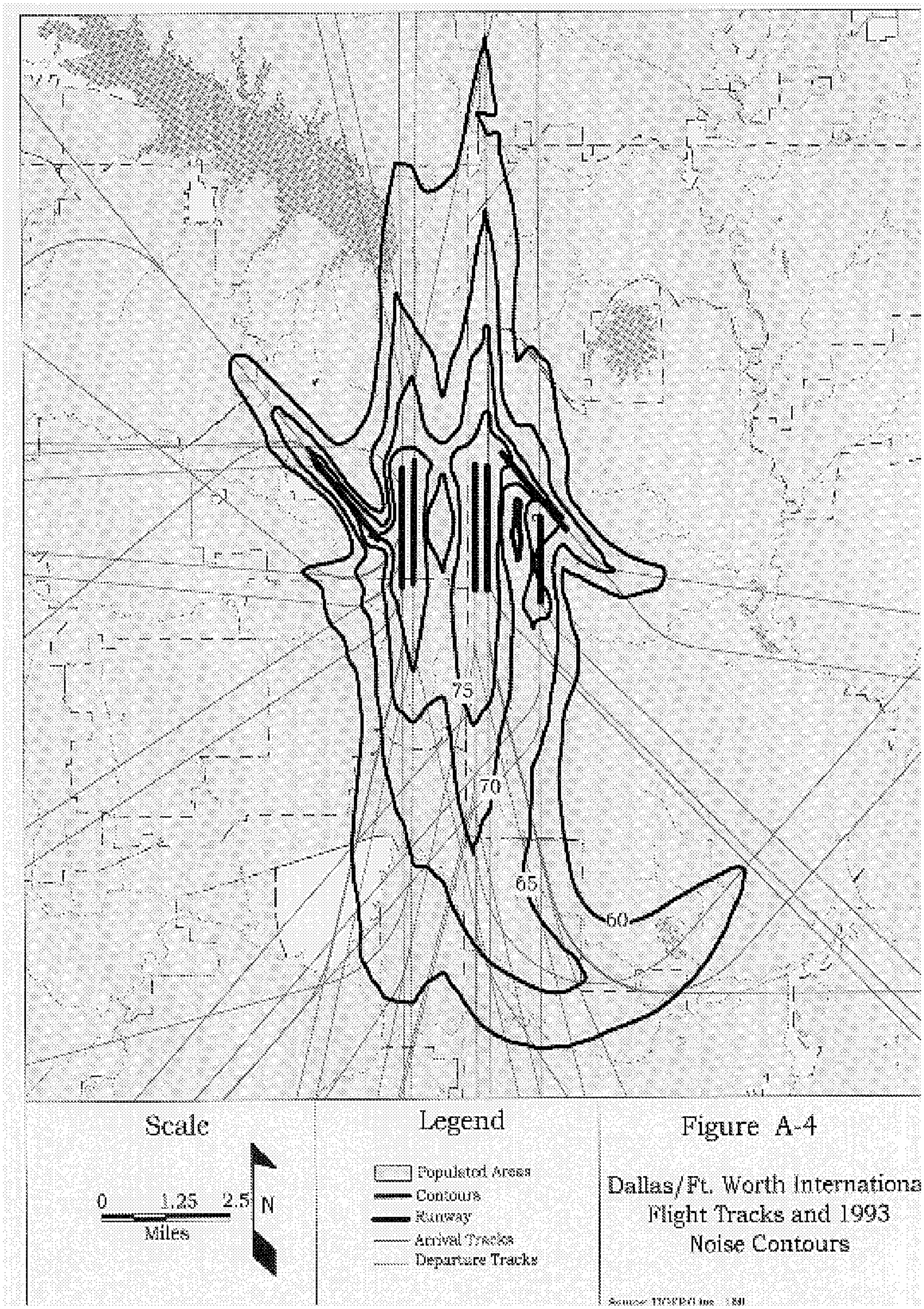


Figure A-5. Detroit Metropolitan Wayne County Airport Flight Tracks and 1993 Noise Contours

Figure A-6. Newark International Airport Flight Tracks and 1993 Noise Contours

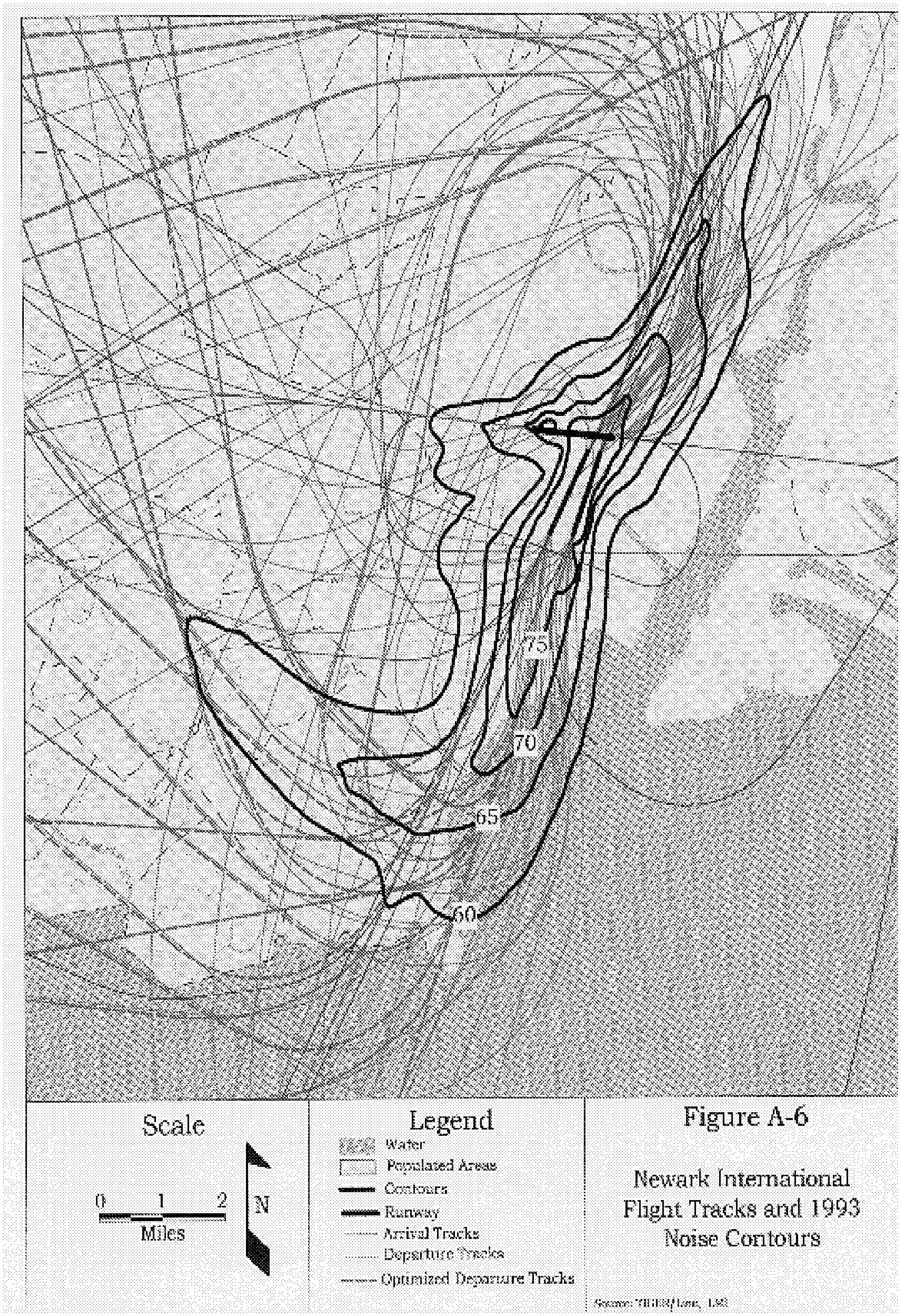


Figure A-7. Dulles International Airport Flight Tracks and 1993 Noise Contours

Figure A-8. John F. Kennedy International Flight Tracks and 1993 Noise Contours

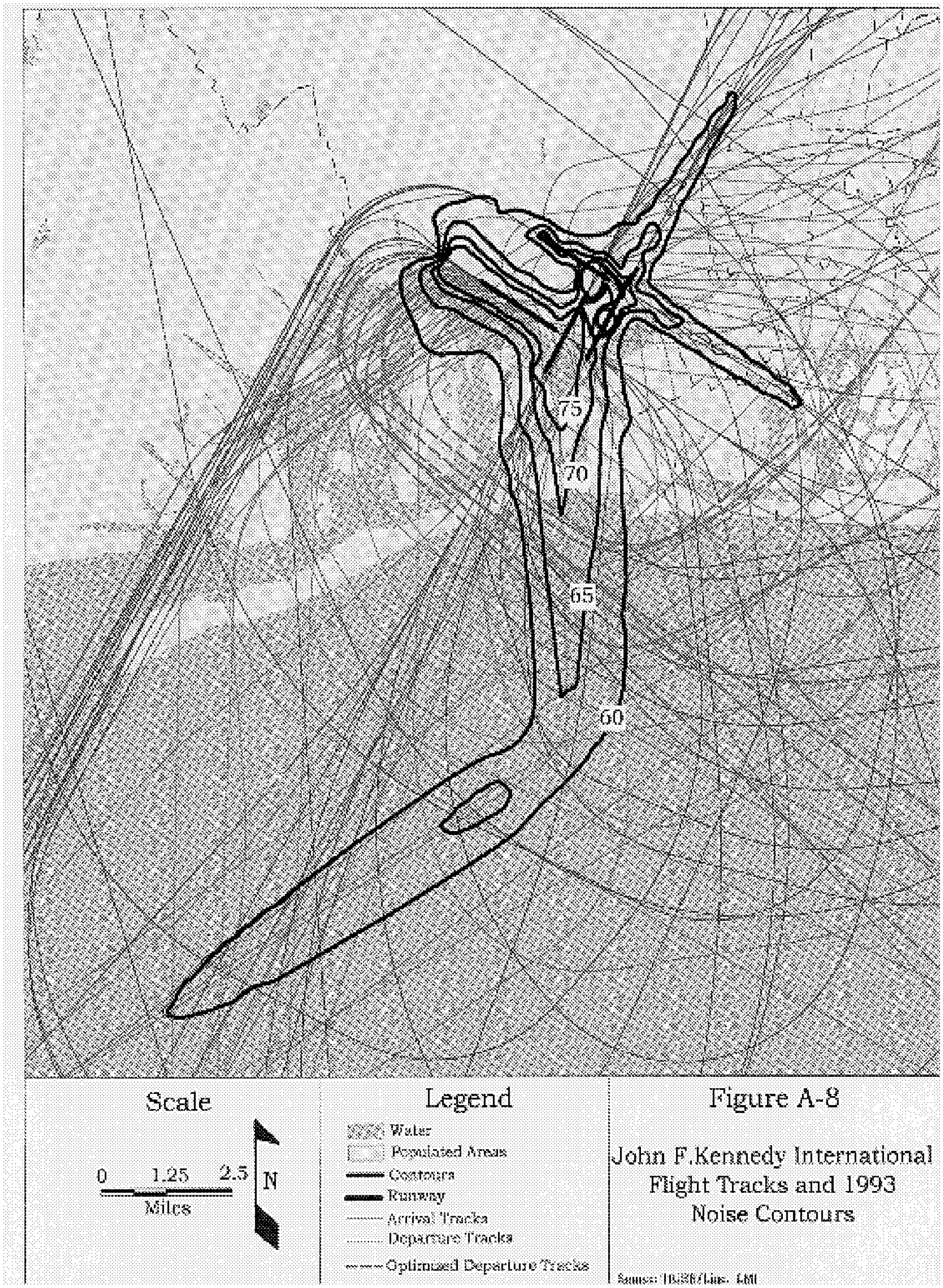


Figure A-9. Los Angeles International Flight Tracks and 1993 Noise Contours

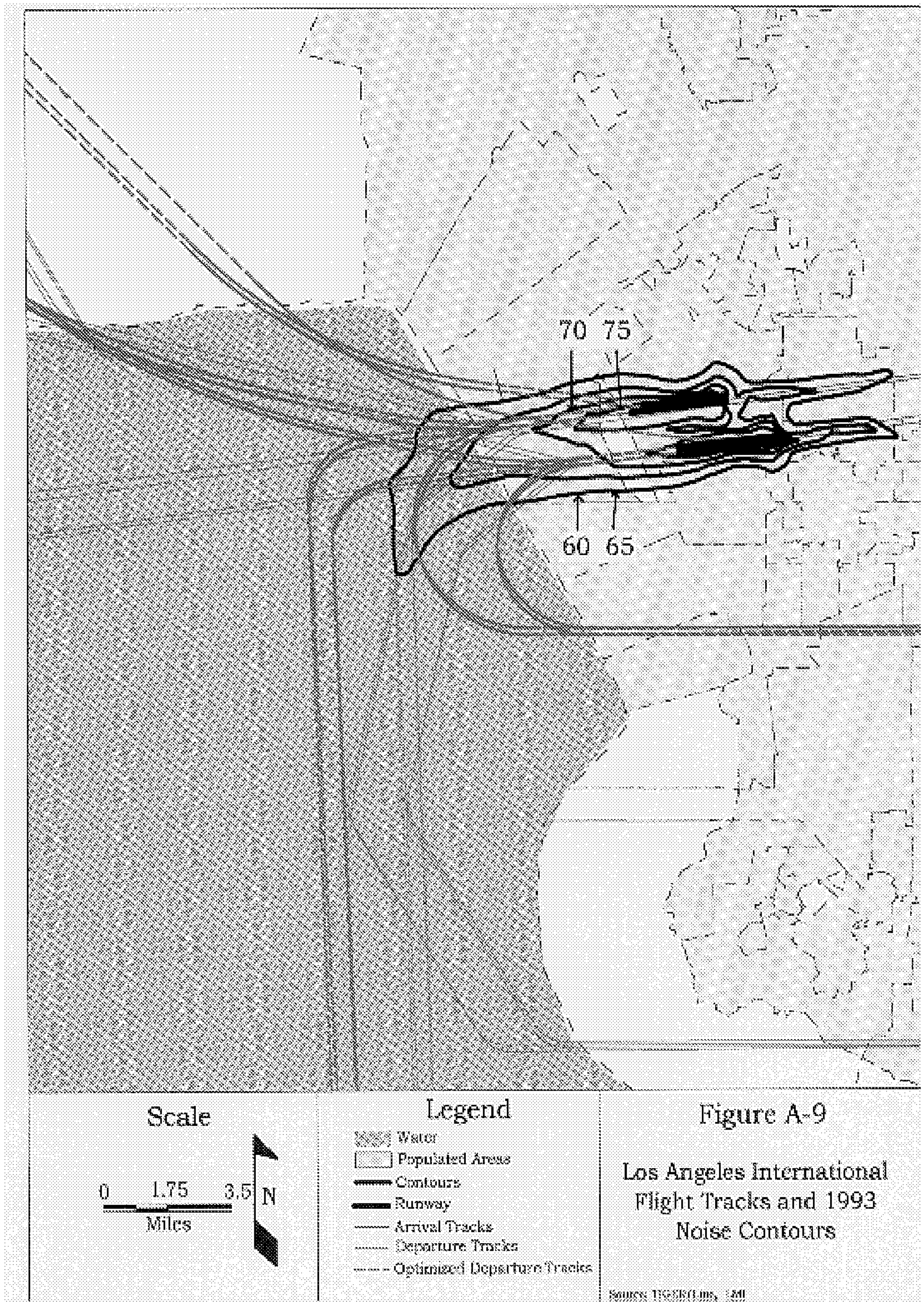


Figure A-10. La Guardia International Flight Tracks and 1993 Noise Contours

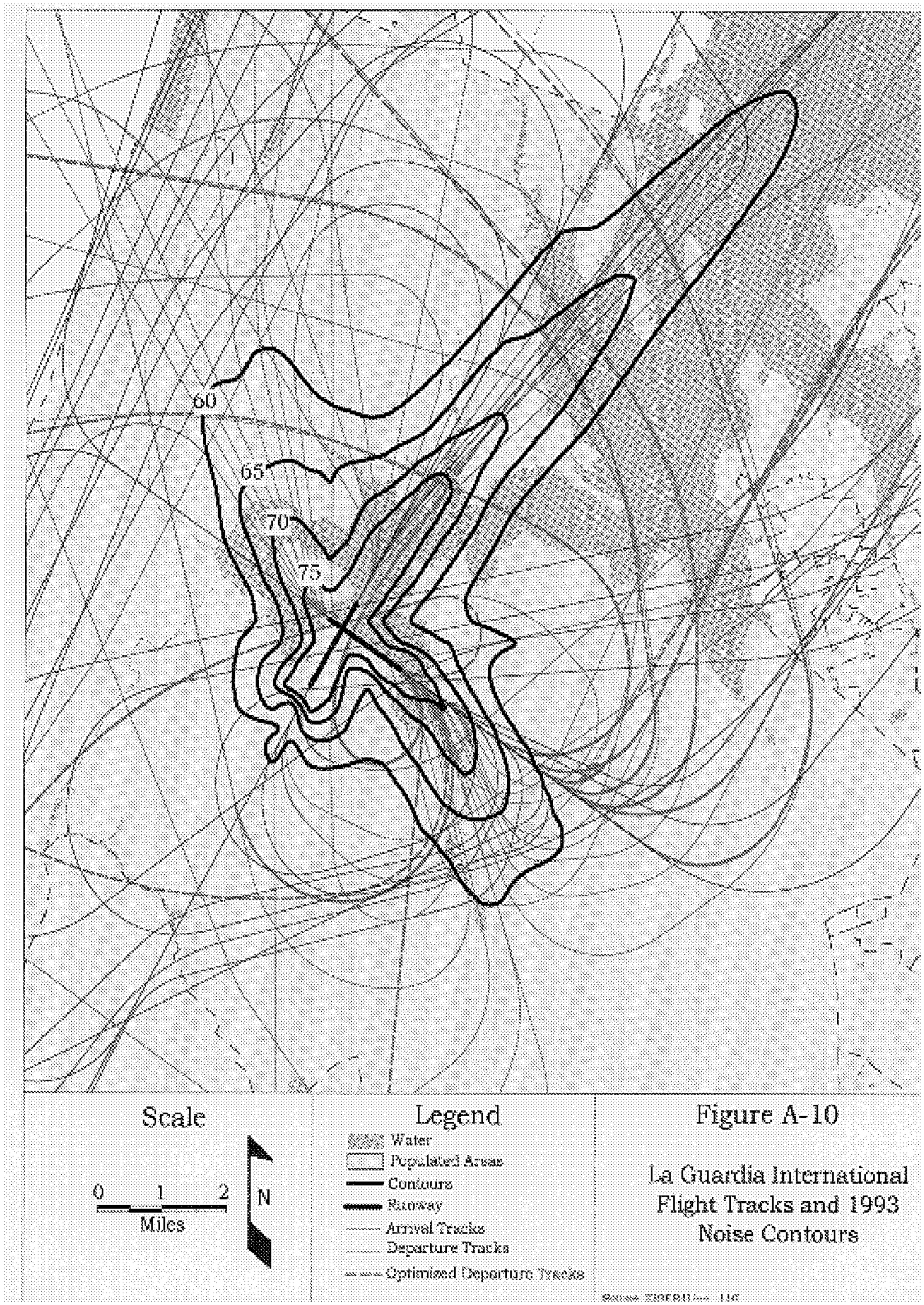


Figure A-11. Orlando International Airport Flight Tracks and 1993 Noise Contours

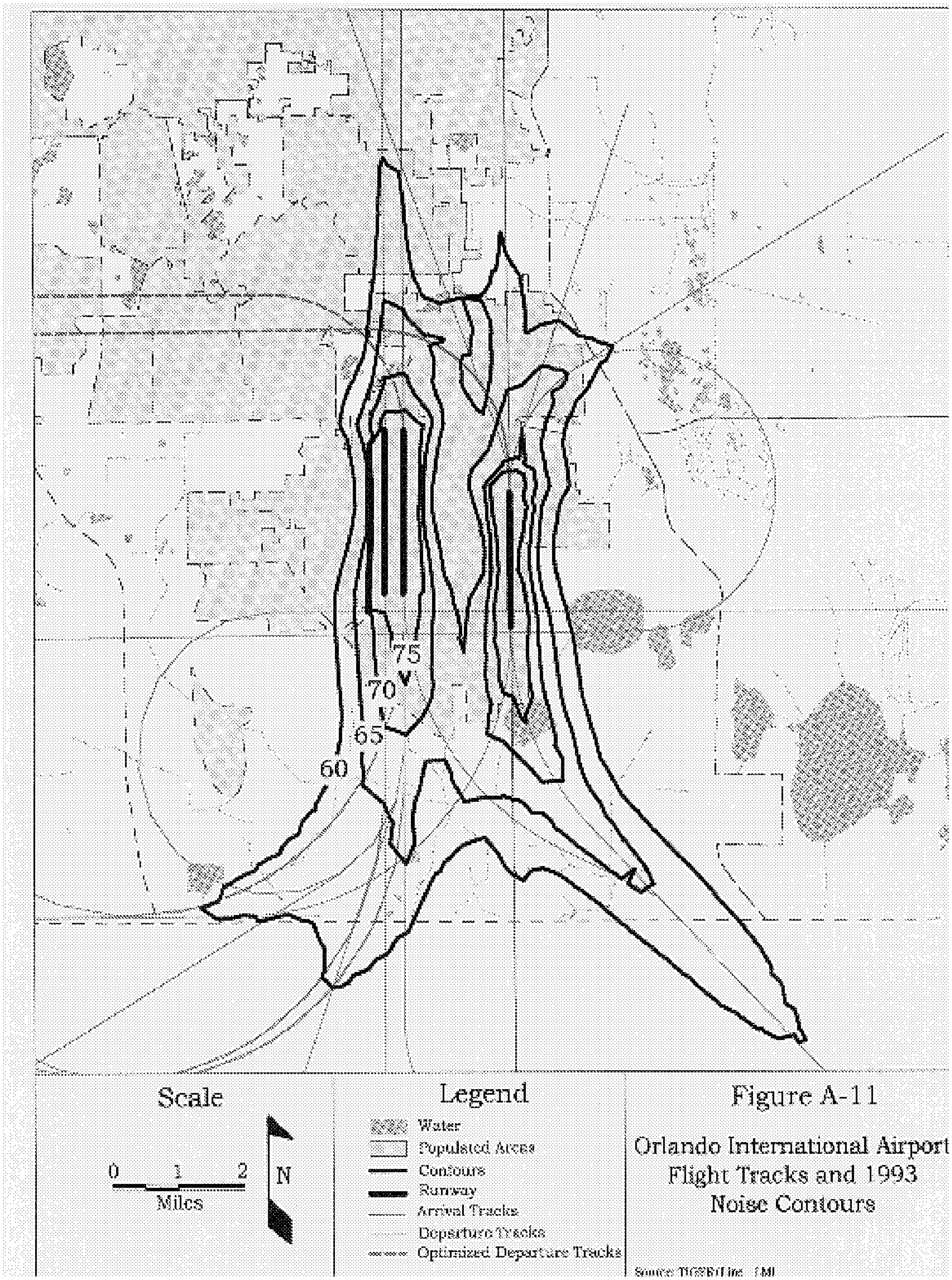


Figure A-12. Minneapolis-St. Paul International Airport Flight Tracks and 1993 Noise Contours

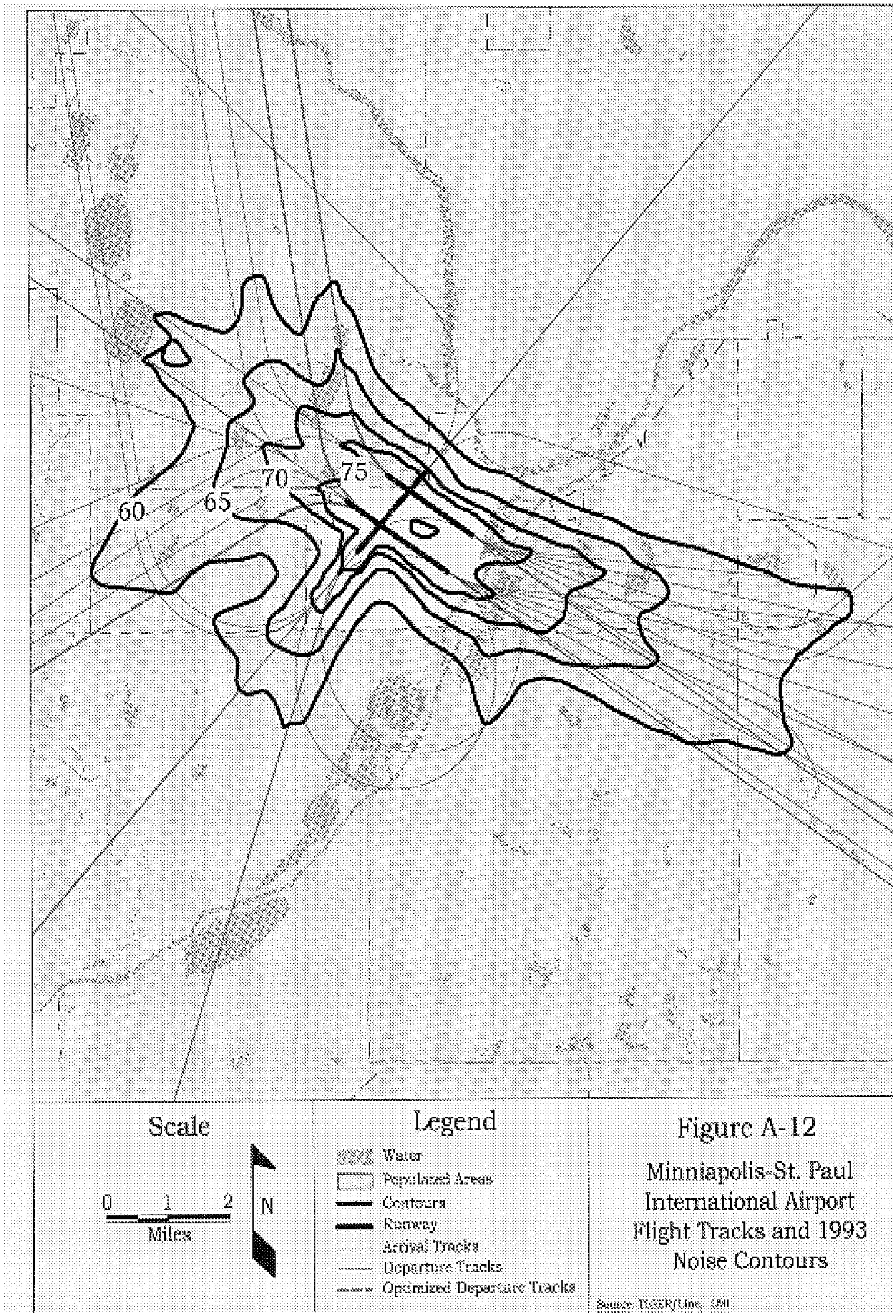


Figure A-13. Chicago O'Hare International Airport Flight Tracks and 1993 Noise Contours

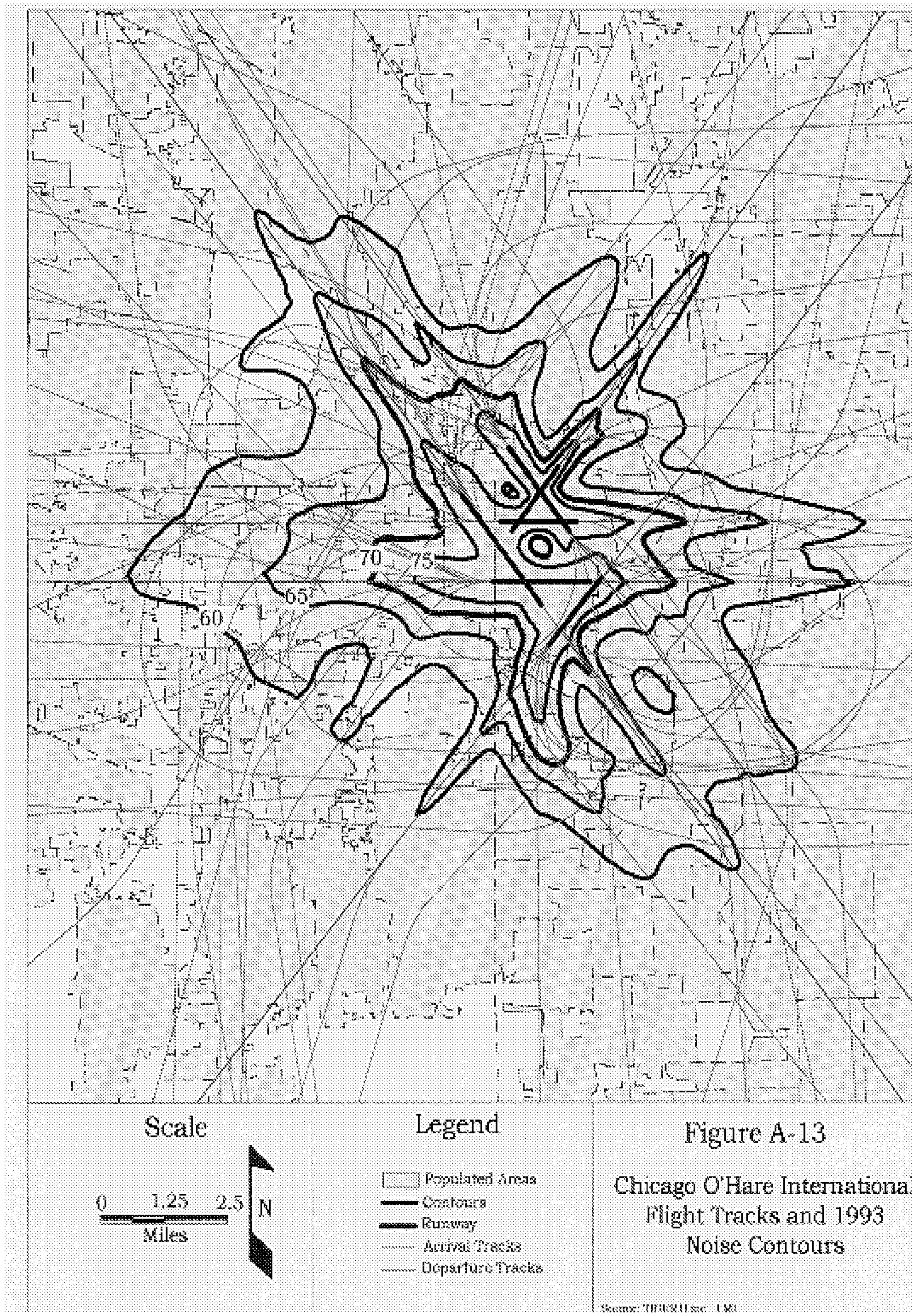


Figure A-14. Pittsburgh International Airport Flight Tracks and 1993 Noise Contours

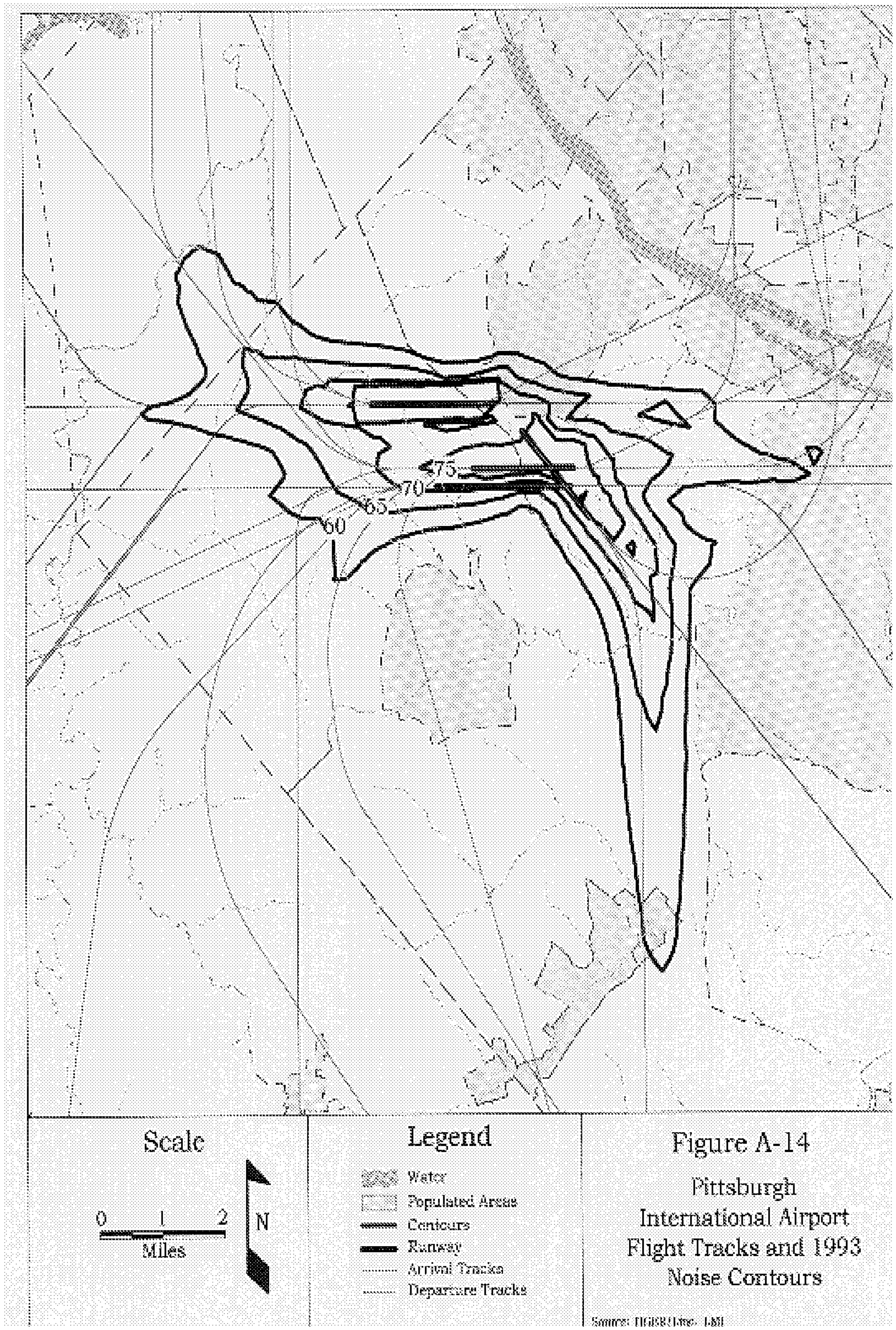


Figure A-15. Seattle-Tacoma International Airport Flight Tracks and 1993 Noise Contours

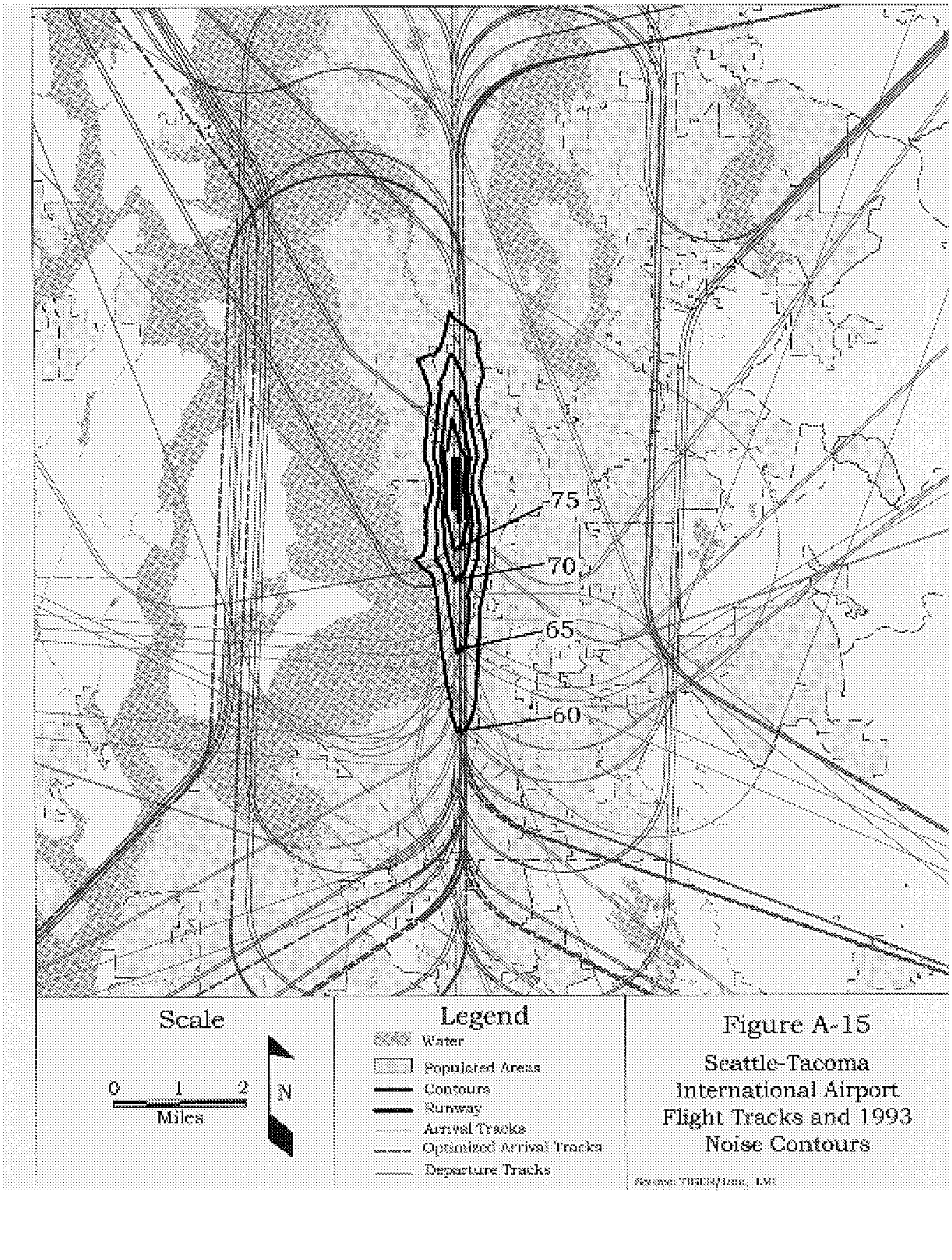
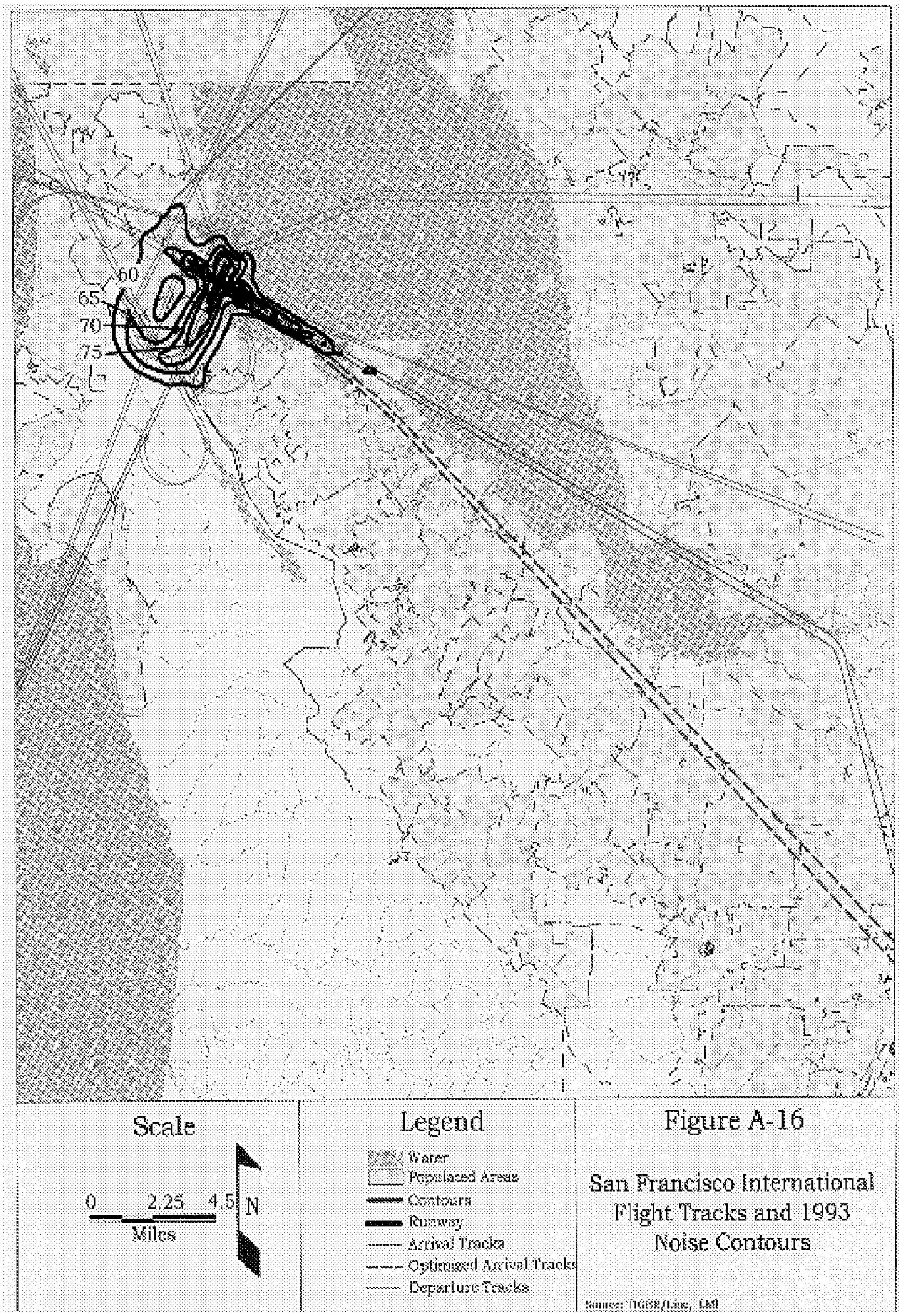


Figure A-16. San Francisco International Airport Flight Tracks and 1993 Noise Contours



Appendix B
Time and Distance Savings

Table B-1. Time and Distance Savings for Optimized Flight Tracks at Study Airports

Airport	Runway	Optimized flight track	Time saved (sec.)	Distance saved (nm)
ATL	26L	Z36X	16	1.92
	26L	Z5BY	14	1.65
	26L	Z5YB	31	3.64
	26L	Z6YB	19	2.19
	26L	Z7YB	25	2.89
	26L	Z8XB	7	0.82
	26L	Z5BY	14	1.65
	27R	Z32Y	20	2.39
BOS	04R	4RD1	41	5.3
	04R	4RD3	41	5.3
	04R	4RD4	41	5.3
	04R	4RD5	41	5.3
	09C	09D1	8	1.0
	09C	09D2	58	7.5
	09C	09D4	58	7.5
	15R	15D1	66	8.6
	15R	15D3	66	8.6
	15R	15D4	66	8.6
	15R	15D5	66	8.6
	22L	2LD1	74	9.6
	22L	2LD2	74	9.6
	22L	2LD3	74	9.6
	22L	2LD4	74	9.6
	22L	2LD5	74	9.6
	22R	2RD1	74	9.6
	22R	2RD2	74	9.6
	22R	2RD3	74	9.6
	22R	2RD4	74	9.6
	22R	2RD5	74	9.6
	27C	27N1	62	8.1
	27C	27N2	62	8.1

Table B-1. Time and Distance Savings for Optimized Flight Tracks at Study Airports (Cont.)

Airport	Runway	Optimized flight track	Time saved (sec.)	Distance saved (nm)
BOS (cont.)	27C	27N3	62	8.1
	27C	27N4	112	14.6
	27C	27N5	112	14.6
	27C	27N6	112	14.6
	27C	27S1	55	7.1
	27C	27S2	55	7.1
	27C	27S3	55	7.1
	27C	27S4	55	7.1
	27C	27S5	55	7.1
	27C	27S6	55	7.1
	33L	33D2	5	0.6
	33L	33D3	5	0.6
CVG	18L	DT10	93	12.0
	18L	DT12	93	12.0
	18L	DT15	38	4.9
	18L	DT19	93	12.0
	18R	DT21	49	6.3
	18R	DT2B	49	6.3
	18R	DT2M	49	6.3
	18R	DT2Q	49	6.3
	27	DT30	13	1.6
	27	DT31	13	1.6
	27	DT32	40	5.1
	27	DT33	3	0.4
	27	DT34	33	10.7
	27	DT35	55	7.1
	27	DT3C	55	7.1
	27	DT3D	13	1.6
	27	DT3M	13	1.6
	27	DT3N	3	0.4
	27	DT3P	13	1.6
	27	DT3Q	83	10.6
	36L	DT51	48	6.3
	36R	DT41	55	7.1
	36R	DT42	55	7.1
	36R	DT43	86	11.1
	36R	DT45	25	3.2

Table B-1. Time and Distance Savings for Optimized Flight Tracks at Study Airports (Con.t)

Airport	Runway	Optimized flight track	Time saved (sec.)	Distance saved (nm)
EWR	04L	4LD3	12	1.45
	04L	4LD4	10	1.15
	04L	4LD5	44	5.24
	04L	4LD6	13	1.56
	04L	4LD7	12	1.46
	04L	4LD8	14	1.70
	04R	4RD3	12	1.45
	04R	4RD4	10	1.15
	04R	4RD5	44	5.24
	04R	4RD6	13	1.56
	04R	4RD7	12	1.46
	04R	4RD8	14	1.70
	22L	2LD3	16	1.88
	22L	2LD4	10	1.22
	22L	2LD5	5	0.55
	22L	2LD6	10	1.21
	22L	2LD7	5	0.57
	22L	2LD8	11	1.31
	22L	2LDA	6	0.76
	22L	2LDO	2	0.27
	22L	2LDS	6	0.70
	22R	2RD3	16	1.88
	22R	2RD4	10	1.22
	22R	2RD5	5	0.55
	22R	2RD6	10	1.21
	22R	2RD7	5	0.57
	22R	2RD8	11	1.31
	22R	2RDA	6	0.76
	22R	2RDO	2	0.22
	22R	2RDS	6	0.70

Table B-1. Time and Distance Savings for Optimized Flight Tracks at Study Airports (Cont.)

Airport	Runway	Optimized flight track	Time saved (sec.)	Distance saved (nm)
JFK	31L	1LD1	17	2.27
	31L	1LD2	17	2.27
	31L	1LD3	21	2.91
	31L	1LD4	7	0.94
	31L	1LD5	21	2.86
	31L	1LD6	30	4.05
	31L	1LDB	13	1.82
	31L	1LDJ	13	1.78
	31R	1RD3	60	8.23
	31R	1RD4	13	1.80
	31R	1RD5	22	3.01
LAX	24L	M24L	29	3.03
	24L	P24L	114	11.85
	24L	V24L	68	7.05
	24R	M24R	29	3.03
	24R	P24R	114	11.85
	24R	V24R	68	7.05
	25L	M25R	45	4.68
	25L	P25L	117	12.12
	25L	V25L	68	7.05
	25R	M25R	45	4.68
	25R	P25R	117	12.12
	25R	V25R	68	7.05
LGA	13	13D1	23	2.78
	13	13D2	22	2.61
	13	13D3	9	1.04
	13	13D4	28	3.30
	13	13D5	71	8.43
	13	13D6	12	1.45
	13	13D7	32	22.00
	13	13D8	10	1.24
	13	13D9	10	1.22
	13	13DA	7	0.86
	13	13DB	5	0.61
	13	13DD	18	2.14
	13	13DG	6	0.76
	13	13DH	20	2.40

Table B-1. Time and Distance Savings for Optimized Flight Tracks at Study Airports (Cont.)

Airport	Runway	Optimized flight track	Time saved (sec.)	Distance saved (nm)
MCO	35L	10	39	5.16
	36R	6	41	5.47
MSP	29L	TR16	2	0.26
	29L	TR17	5	0.66
	29L	TR18	8	1.05
	29L	TR20	7	0.86
	29R	TR23	4	0.53
	29R	TR24	7	0.86
SEA	16L	JA04	22	2.94
	16L	JA12	30	4.00
	16R	JA54	22	2.94
	16R	JA62	30	4.00
	34L	JA55	95	12.77
	34L	JA57	31	4.10
	34L	JA59	43	5.81
	34L	JA61	20	2.64
	34L	JA63	20	2.65
	34L	JA65	62	8.30
	34R	JA05	47	6.30
	34R	JA07	33	4.50
	34R	JA09	46	6.21
	34R	JA11	46	6.25
	34R	JA13	23	3.05
	34R	JA15	62	8.30
SFO	28L	A1IN	10	1.24
	28R	A1NE	10	1.22

Appendix C

Airport Profiles

Table C-1. Airport Profiles

Name	Data
The William B. Hartsfield Atlanta International Airport	Airport,"ATL" Altitude,1026,"Temperature",16,"C" Runways,4 RW,"09R","27L",0,0,8700,0,92 RW,"09L","27R",0,1000,11700,1000,92 RW,"08R","26L",2740,5295,12650,5290,92 RW,"08L","26R",2076,6515,11610,6510,92
General Edward Lawrence Logan International Airport	Airport,"BOS" Altitude,15,"Temperature",59.0,"F" Runways,6 RW,"04R","22C",0,0,2966, 8285,35 RW,"04C","22L",474,1323,3440,9608,35 RW,"04L","22R",-545,2927,2028,10114,35 RW,"09C","27C",-145,1921,6589,3534,92 RW,"15R","33C",-1548,8613,5530,1504,151 RW,"15C","33L",-956,8017,5530,8017,151
Cincinnati/Northern Kentucky International Airport	Airport,"CVG" Altitude,890,"Temperature",12,"C" Runways,3 RW,"18R","36L",70,9500,0,0,180 RW,"09","27",-3265,4315,4530,4250,90 RW,"18L","36R", 6305,7745,6230,-2265,180
Dallas/Fort Worth International Airport	Airport,"DFW" Altitude,603,"Temperature",19,"C" Runways,7 RW,"34","16",13196,-1285,13196,6294,340 RW,"35R","17L",7815,-129,7816,10661,354 RW,"35L","17R",6406,-129,6406,10789,354 RW,"36R","18L",0,0,128,10789,354 RW,"36L","18R",-1154,128,-1153,10661,354 RW,"31L","13R",-3588,4366,-9609,10789,313 RW,"31R","13L",15374,5780,9225,11945,309

Table C-1. Airport Profiles (cont.)

Name	Data
Detroit Metropolitan Wayne County Airport	Airport,"DTW" Altitude,639,”Temperature”,48.6,"F" Runways,4 RW,"09","27",2180,5380,10880,5380,094 RW,"03L","21R",0,0,5830,10490,034 RW,"03C","21C",5280,1940,9500,9370,034 RW,"03R","21L",5020,-2460,10120,6260,034
Newark International Airport	Airport,"EWR" Altitude,18,”Temperature”,13,"C" Runways,6 RW,"04R","22L",0,0,3996,8398,39 RW,"03R","21L",-451,1904,3485,7323,39 RW,"04L","22R",-1620,1637,2823,8122,39 RW,"03L","21R",-1301,2305,2634,7725,39 RW,"11","29",-1881,9081,4899,8553,108 RW,"10","28",-1881,9081,4601,8577,108
Washington Dulles International Airport	Airport,"IAD" Altitude,313,”Temperature”,60,"F" Runways,3 RW,"01L","19R",0,0,140,11499,10 RW,"01R","19L",6632,-5581,6773,5918,10 RW,"12","30",-8791,1689,578,-1807,120
John F. Kennedy International Airport	Airport,"JFK" Altitude,13,”Temperature”,13,"C" Runways,7 RW,"04L","22R",0,0,5805,9755,44 RW,"05L","23R",0,0,4260,7158,44 RW,"04R","22L",4222,1241,8518,8459,44 RW,"13L","31R",-1255,13035,7338,7920,134 RW,"14L","32R",-405,12528,6458,8444,134 RW,"13R","31L",-8643,9635,3879,2183,134 RW,"14R","32L",-6404,8303,1023,3883,134
Los Angeles International Airport	Airport,"LAX" Altitude,126",TEMPERATURE",17,"C" Runways,8 RW,"06L","24R",-3649,5566,4790,6611,69 RW,"06R","24L",-4959,4689, 4925,5971,69 RW,"07L","25R",-68,708,11570,2159,69 RW,"07R","25L",0,0,11503,1416,69 RW,"08L","26R",-68,708,10984,2087,69 RW,"08R","26L",0,0,10920,1345,69 RW,"06C","24C",-5296,5002,4834,6254,69 RW,"07C","25C",-34,354,11537,1787,69

Table C-1. Airport Profiles (cont.)

Name	Data
La Guardia Airport	Airport,"LGA" Altitude,"22,"Temperature",13,"C" Runways,3 RW,"04","22",0,0,3701,5942,45 RW,"13","31",1572,4792,7514,1091,135 RW,"14","30",1572,4792,7365,1184,135
Orlando International Airport	Airport,"MCO" Altitude,96,"Temperature",23.0,"C" Runways,3 RW,"36L","18R",0,0,0,12204,359 RW,"36R","18L",1500,0,1500,12204,359 RW,"35L","17R",10040,-2500,9950,7500,359
Minneapolis–St. Paul International Airport	Airport,"MSP" Altitude,841,"Temperature",60,"F" Runways,4 RW,"04","22",0,0,5140,5120,41 RW,"11R","29L",-880,3790,7700,-1450,118 RW,"11L","29R",2580,5610,9550,1350,118 RW,"04C","22C",0,0,5950,5900,41
Chicago O'Hare International Airport	Airport,"ORD" Altitude,668,"Temperature",10,"C" Runways,6 RW,"04L","22R",0,0,4770,5787,41 RW,"04R","22L",3938,-10327,9286,-4283,43 RW,"09L","27R",-1209,814,6758,855,91 RW,"09R","27L",-1935,-4610,8205,-4590,91 RW,"14L","32R",-397,7568,6033,-95,141 RW,"14R","32L",-5228,3198,3129,-6759,141
Greater Pittsburgh International Airport	Airport,"PIT" Altitude,18,"Temperature",82.7,"F" Runways,5 RW,"10L","28R",0,0,10500,0,100 RW,"10C","28C",8773,-4309,16812,-4311,100 RW,"10","28",8773,-4309,17412,-4311,100 RW,"10R","28L",5622,-5503,17122,-5503,100 RW,"14","32",12973,-1855,18758,-7526,140
Seattle–Tacoma International Airport	Airport,"SEA" Altitude,430,"Temperature",11,"C" Runways,2 RW,"34L","16R",0,0,0,9425,338 RW,"34R","16L",800,-2475,800,9425,338

Table C-1. Airport Profiles (cont.)

Name	Data
San Francisco International Airport	Airport,"SFO" Altitude,11,"Temperature",16,"C" Runways,4 RW, "10L","28R",0,0,11689,-2061,100 RW, "10R","28L",1113, -1008,11552,-2849,100 RW, "01L","19R",5643, -5391,6859,1503,10 RW, "01R","19L",6226, -6589,7771,2176,10

Appendix D

Abbreviations

ASAC	=	Aviation System Analysis Capability
DNL	=	day-night average sound level
EA	=	economic areas, U.S. census
FTNIM	=	Flight Track Noise Impact Model
GIS	=	Geographic Information System
INM	=	Integrated Noise Model
NIM	=	Noise Impact Model
OAG	=	Official Airline Guides

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13. ABSTRACT ***(Maximum 200 words)***
To meet its objective of assisting the U.S. aviation industry with the technological challenges of the future, NASA must identify research areas that have the greatest potential for improving the operation of the air transportation system. To accomplish this, NASA is building an Aviation System Analysis Capability (ASAC).
The Noise Impact Model (NIM) has been developed as part of the ASAC. Its primary purpose is to enable users to examine the impact that quieter aircraft technologies and/or operations might have on community noise impact and air carrier operating efficiency at any of 16 large- and medium-sized U.S. airports. The analyst chooses an airport and case year for study, selects a runway use configuration and set of flight tracks for the scenario, and has the option of reducing the noise of the aircraft that operate at the airport by 3, 6, or 10 decibels. NIM computes the resultant noise impact and estimates any airline operations improvements. Community noise impact is characterized in three ways: the size of the noise contour footprint, the number of people living within the contours, and the number of homes located in the same contours. Distance and time savings are calculated by comparing the noise abatement flight path length to a less circuitous alternate routing. For a more efficient runway use configuration, the increase in capacity and reduction in delay are shown.

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